This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

GB
23
.G46

A 408052

TWENTIETH CENTURY TEXT-BOOKS

TEACHERS' GUIDE AND LABORATORY EXERCISES

TO ACCOMPANY

AN INTRODUCTION TO PHYSICAL GEOGRAPHY

BY

GROVE KARL GILBERT

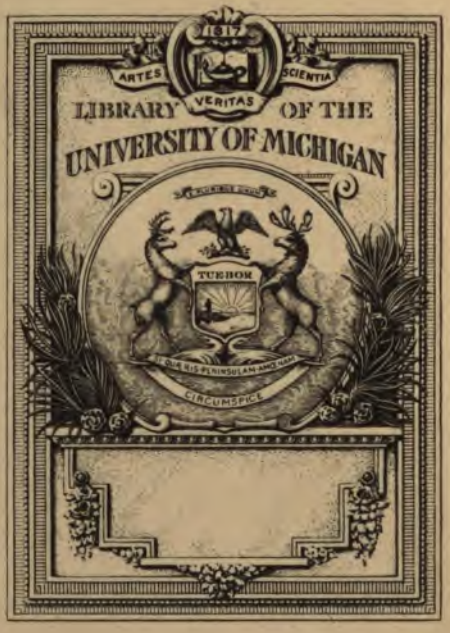
UNITED STATES GEOLOGICAL SURVEY

AND

ALBERT PERRY BRIGHAM

PROFESSOR OF GEOLOGY IN COLGATE UNIVERSITY

NEW YORK
D. APPLETON AND COMPANY
1903


ARTES
SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
CIRCUMSPICE

GB
23
.G46

TWENTIETH CENTURY TEXT-BOOKS

EDITED BY

A. F. NIGHTINGALE, PH. D., LL.D.

FORMERLY SUPERINTENDENT OF HIGH SCHOOLS, CHICAGO

TWENTIETH CENTURY TEXT-BOOKS

TEACHERS' GUIDE AND LABORATORY EXERCISES

TO ACCOMPANY

AN INTRODUCTION TO PHYSICAL GEOGRAPHY

BY

GROVE KARL GILBERT

UNITED STATES GEOLOGICAL SURVEY

AND

ALBERT PERRY BRIGHAM

PROFESSOR OF GEOLOGY IN COLGATE UNIVERSITY

NEW YORK

D. APPLETON AND COMPANY

1903

COPYRIGHT, 1903
BY D. APPLETON AND COMPANY

Published January, 1903

GB
23
.G46

PREFATORY NOTE

THIS Guide has been prepared for use with Gilbert and Brigham's *Introduction to Physical Geography,* of the Twentieth Century Series, and is therefore made parallel in arrangement with the chapters and sections of that volume. Most of the laboratory exercises and supplementary suggestions are, however, equally available for use with other school texts.

THE AUTHORS.

151902

CONTENTS

	PAGE
The Equipment of the Teacher	1
The Equipment of the School	3
Lantern and Views	4
Models	5
Maps	5
Specimens	7
Books and Other Material	7
General References	7
Laboratory Work	10
Relation of the Study to the School Course	11
Special Suggestions by Chapters	13
Chapter I, The Earth	13
Chapter II, The Earth and the Sun	21
Chapter III, Rivers	25
Chapter IV, Weathering and Soils	34
Chapter V, Wind Work	39
Chapter VI, Glaciers	41
Chapter VII, Plains	49
Chapter VIII, Mountains and Plateaus	52
Chapter IX, Volcanoes	57
Chapters X and XI, The Atmosphere	60
Chapter XII, The Earth's Magnetism	79
Chapter XIII, The Ocean	81
Chapter XIV, The Meeting of the Land and Sea	86
Chapters XV and XVI, The Earth and Organisms	89
Index	97

LIST OF ILLUSTRATIONS

FIG.		PAGE
1.	Geometry of the "artificial horizon"	15
2.	Interpolation	19
3.	Diagram illustrating determination of latitude	20
4.	Diagram illustrating measurement of star distances	22
5.	Construction to find the foci of an ellipse	23
6.	The drawing of an ellipse	23
7.	Arrangement of lamp and globe to illustrate the seasons	24
8.	Measurement of height with a hand-level	27
9.	Clinometer	28
10.	Ages of members of a class	70
11.	Amount of day and night	70

TEACHERS' GUIDE IN PHYSICAL GEOGRAPHY

THE EQUIPMENT OF THE TEACHER

THE usefulness of Physical Geography in our schools will depend upon the knowledge and skill of the teacher. No material equipment can be a substitute for teachers who know geography and teach it with contagious interest. Many teachers have attained this kind of knowledge and power. Others are conscious of their deficiencies, and it is chiefly to aid such that this guide is prepared.

Those who teach only geography and geology are free to gain suitable preparation. But such teachers are few. Many must, as the case now stands, give the most of their time to their classes in physics and chemistry in schools where geography is little appreciated and few facilities are offered for instruction. For such, attainments in geography must be gradual, but are always possible. Let the teacher take up at once some phase of geography for concrete, first-hand study. The locality will often decide what this shall be. In New England or New York the glacial formations offer an exhaustless theme. On the ocean border the shore line is a natural choice, and the teacher may purchase *Sea and Land* (by N. S. Shaler), and after a few excursions and some reading find himself in the heart of our science.

If the teacher is in the oil country, as at Bradford, or Oil City, Pa., he finds there a subject in which he may

become, in some sense, an expert, and he will be surprised at the breadth of the geographic conceptions into which a single subject will lead him. Thus the oil will compel him to consider the rocks pierced by the borings and the origin of the oil, thus carrying him both into geology and chemistry. On the other hand, he finds a great range of mechanical contrivance, problems of transportation, distribution and use, introducing him to the broad fields of commercial geography.

The same results will appear if he devotes himself to a knowledge of the salt of New York, the coal of the Mississippi Valley, the arid regions of the West, with their great and fresh irrigation problems, or to the forests of the United States, with the questions of forestry and the development of forest reservations.

Pursuing such a course, which is feasible for the busiest teacher, teaching will be enriched in one geographic field and vitalized in all. We advise, then, as the first object of the teacher of geography, a first-hand acquaintance, both in the literature and in the field, with some great geographic theme. Progress will then be easy and inevitable.

With such work will come the beginnings of a library. They need not be expensive. *The Journal of Geography* (see general references, p. 9) is advised for all, as being the one geographic periodical in America which takes special account of the needs of teachers. A few of the best modern text-books should be always at hand for comparison and for fresh illustration of particular topics. It is well also to secure any Government and State reports which deal with the home State or district. Suggestions for obtaining the last are given on p. 9.

A surprising amount of geographic material will be found, by watchful teachers, in daily papers and the various journals. Thus, within a day of this writing has ap-

peared notice of a destructive sand-storm in California, and for weeks the volcanic disturbances of the West Indies have been fruitful subjects of discussion.

Working along the lines already suggested, the teacher will find himself coming into acquaintance and correspondence with fellow workers in the same field. Here we note the American Association for the Advancement of Science, the Science Department of the National Educational Association, and the more limited but more regularly accessible local organizations, such as the New York State Science Teachers' Association. In like manner teachers may count upon courteous assistance in applying to teachers of geography and geology in the colleges and universities. Such help is especially attainable through summer courses of instruction, now given regularly by a number of the larger universities, either at the university or in extended field trips. Attention is here called to a review of summer courses offered in geography in 1902, found in *The Journal of Geography* for May, 1902. Similar courses may be expected each year.

THE EQUIPMENT OF THE SCHOOL

Only general suggestions are given at this point. Specific advice as to the maps, etc., needed in the various subjects and the apparatus essential to work on the atmosphere will be given by chapters. Teachers should consult *Equipment of a Geographical Laboratory*, by W. M. Davis, *Journal of School Geography*, vol. ii, May, 1898, pp. 170–181, where a diagram is shown of a lecture-room and laboratory combined.

Occasionally the resources available will admit of early and ample equipment. Most commonly the funds are limited, and careful selection and ingenuity on the part of the teacher must atone for the deficiency. Whatever the restriction, purchase only the best maps, models,

and instruments, even though accessions be infrequent. Effective use of good appliances will best show the need of more equipment, and principals and members of school-boards will be convinced that geography must have its quota of appliances if it is to be taught in a truly scientific manner. It is one object of this guide to show that much good work may be done with a modest outfit.

Lantern and Views

A projecting lantern will belong to all the better high schools. The geographical lecture-room will be the natural place for it, even though the same lantern may be used somewhat by other departments. An electric lantern is by all means the best where the currents are available in the day hours. Besides the easier handling, ventilation can be had, and light enough can be admitted to allow note-taking to proceed. The acquirement of good slides is not easy. As a rule slides should not be ordered without being seen and selected by the teacher. Catalogues of slides selected for geographic teaching are furnished by Edwin E. Howell, 612 Seventeenth Street, N. W., Washington, D. C., and by T. H. McAllister, 49 Nassau Street, New York. Many colleges and schools now have considerable collections of geographic slides, and in some cases, at least, duplicates can be secured through inquiry addressed to teachers of geography and geology in such schools. Specific directions can hardly be given, and progress should be made carefully even at the cost of delay.

Similar is the case with photographs. Many of the best photographs have been reproduced in text-books, and are thus available. Where classes are large, duplicate copies of the principal texts should be provided by the school for class and laboratory use. Mr. William H. Rau, of Philadelphia, issues a large catalogue of American

and foreign photographs and slides, with sizes and prices. Other dealers are the W. H. Jackson Photograph Company, of Denver; the Soule Photograph Company, of Boston; and Hegger, Fifth Avenue, New York. But the most useful views may often be obtained from local dealers and photographers, and from teachers of geography.

Models

The best or none, should be the rule. Teachers should refrain from advising the purchase of models sold by school-supply firms unless well satisfied of their value. They are often so incorrect in expression, particularly in exaggeration of slopes and altitudes, as to be harmful rather than useful. A large number of the best models are made by Mr. Howell, already named. Some of the less expensive and most generally useful of these will be named in later pages, as well as models from other sources. Mr. Howell sells five models of the continents, in a set, for $150. A good globe is the most generally useful of all models and should be regarded as indispensable.

Maps

These are the most important part of the apparatus for the teaching of geography. As compared with other nations, our own Government uses a most liberal policy in the distribution of its scientific publications. Hence Government maps can commonly be secured at a nominal expense, which barely covers their cost. Most important of these are the atlas sheets, now available to the teacher for many parts of the United States. Sample parts of some of these are given in the text-book. See especially Sec. 13 and Fig. 11. Address The Director, United States Geological Survey, Washington, D. C. The sheets are sold in small numbers at 5 cents each, but in lots of 100

or more at 2 cents each. Remit only by post-office money-order, made payable to *Director United States Geological Survey.* If in doubt as to whether maps of a given region have been prepared, address the director for information. As to selection of these maps, suggestions will be given by chapters, and a useful guide is found also in *Use of Governmental Maps in Schools,* by Davis, King, and Collie, published by Henry Holt & Co., New York, 30 cents. This pamphlet also tells about the maps of the Mississippi River Commission, the United States Lake Survey, and the United States Coast Survey.

The atlas sheets can conveniently be mounted on cloth or cardboard, and rendered durable for class use. Others, not mounted, can be kept in cardboard or heavy paper folios. The latter may be labeled on the outside and kept in trays or drawers, accessible at all times for lectures and laboratory exercises. All the sheets from one's own State and the more typical and instructive sheets from other States should be in every high-school collection. A group of adjacent sheets make a useful wall map of certain larger areas, as of the Finger Lake Regions of New York, the eastern coast line of Massachusetts north and south of Boston, or the mountain region of Pennsylvania.

Several maps of small scale, but covering large areas, are indispensable. The *Three-Sheet Map of the United States* should be ordered from the Geological Survey, price 60 cents. The scale is about forty miles to an inch, and it shows the drainage in blue, and the relief in brown contour lines. Kiepert's or other good maps of all the continents should be included. The teacher will watch for good maps from all sources. Thus the National Geographic Society can furnish several in connection with special numbers of its magazine, as of Alaska and the submarine cable lines of the world. Davis, King, and Collie should be consulted for many other suggestions.

Specimens

A few common minerals and rocks should be secured. Any common ores, building stones, plastic clays, mineral paints, crude petroleum, abrasives, as honestone or corundum (emery), will be useful. On the collection, purchase and arrangement of such material the teacher is referred to *Suggestions to Teachers, accompanying Brigham's Text-Book of Geology,* pp. 4–6. Woods, seeds, fibers, and other vegetable materials are useful, and similar directions might be given for their acquirement and care.

Books and Other Material

Books and papers are in high degree essential. A list of important titles is given below and special references appear by chapters. Outside of any bibliography that can here be given the teachers will find much in works of travel, works on various phases of human culture, and even in more general literature. A geographical drawer or scrap-book may be kept for clippings that would be useful in the class. Very useful pictures also can be found in the circulars and guide-books issued by railway and steamship lines, and in the various periodicals. These are often quite as vivid and useful in teaching as costly photographs. They can be mounted, labeled, and classified for permanent use.

General References

Elementary Physical Geography and *First Book of Physical Geography.* Tarr. Macmillan.

Physical Geography and *Elementary Physical Geography.* Davis. Ginn & Co.

Lessons in Physical Geography. Dryer. American Book Co.

Text-Book of Geology. Brigham. And accompanying *Suggestions to Teachers.* D. Appleton and Company.

Introduction to Geology. Scott. Macmillan.

Elementary Geology. Tarr. Macmillan.

Text-Book of Geology. Dana. Revised by Rice. American Book Co.

The larger manuals of Geology. By Le Conte, Dana, and Geikie.

(Not all the above books are needed. The teacher will find it useful to have at hand Tarr, Davis, and Dryer's Geographies, for parallel treatment, and at least one of the geological texts.)

The International Geography. H. R. Mill, Editor. D. Appleton and Company. The best single volume for modern treatment of regional geography.

Physiography of the United States. Various authors. Not a complete account, as the title implies, but a useful series of ten monographs on special regions. American Book Co.

Stanford's Compendium of Geography. Volume on United States. Gannett. Edward Stanford.

North America, in *Descriptive Geographical Series.* F. D. and A. J. Herbertson. A. & C. Black, London. A valuable compilation of extracts on many phases of American geography.

North America. In Tarr and McMurry Series. Macmillan.

Geographical Reader. Dodge. Longmans, Green & Co. Modern treatment of the more important topics in Physical Geography.

The Use of Governmental Maps in Schools. Davis, King, and Collie. Henry Holt & Co. 30 cents. Useful guide for every teacher in selection and purchase of maps.

Physical Geography of New York. R. S. Tarr. Macmillan.

Studies in Indiana Geography. C. R. Dryer. Inland Publishing Co., Terre Haute.

Physiography of Missouri. C. F. Marbut. *Geological Survey of Missouri,* vol. x.

Physical Geography of New Jersey. R. D. Salisbury. *Final Report of Geological Survey of New Jersey,* vol. iv. With map.

Geological Guide-Book to the Rocky Mountains. By several geologists. John Wiley & Sons.

Scenery of Scotland. A. Geikie. Third edition.
Scenery of England. Lord Avebury. Macmillan.
Earth Sculpture. J. Geikie. Putnam.
United States of America. N. S. Shaler. 2 vols. D. Appleton and Company.
A Geographical Reader. James Johonnot. American Book Co.
Topographic Atlas of the United States, Physiographic Types. H. Gannett. Folios i and ii, 25 cents each. *Physical Geography of the Texas Region.* R. T. Hill. Folio iii of same series, 50 cents. All very important, and needed in several laboratory exercises. Published by United States Geological Survey.

(The United States Geological Survey publishes, and sends free of charge, a catalogue of all books and maps issued. Requests for this catalogue and all other communications and remittances should be addressed to the Director, United States Geological Survey, Washington, D. C. Remit only by United States post-office money order, no matter how small the amount. Maps, folios, and monographs are sold, as per prices in catalogue. Annual reports and bulletins are given away, but application must be made to the Congressman of your own district.)

The Journal of Geography. Dodge, Goode, and Lehnerts, Editors. Monthly, continuing the *Journal of School Geography* and the *Bulletin American Bureau of Geography.* Specially devoted to the interests of teachers.
National Geographic Magazine. Monthly. By the National Geographic Society, Washington.
Bulletin of the American Geographical Society. Five numbers a year. New York.
Science. Weekly. New York. Free to members of the American Association for the Advancement of Science.

The following eight articles are in the *Journal of School Geography,* as indicated:

Laboratory Work in Elementary Physiography. Cornish. Vol. i, 172 and 204.
The Equipment of a Geographical Laboratory. Davis. Vol. ii, 170.
The Better Books in School Geography. Platt. Vol. ii, 181.

Preliminary Report of Committee (National Educational Association) on Physical Geography. Vol. ii, 248.
Some Suggestions for Excursions with Elementary Classes. Emerson. Vol. iii, 287.
Geological Laboratory Work in Worcester Academy. Snyder. Vol. iii, 368.
Exercises on United States Topographical Maps. Blount. Vol. v, 128.

LABORATORY WORK

This heading is used to include not only indoor exercises, with apparatus, etc., but field work, or excursions for outdoor study. The proportions of indoor and outside study will depend on the equipment and the locality. Practical exercises should not be omitted because the ideal can not be at once attained. If few maps and other materials are at hand and regular laboratory hours are impracticable, begin with occasional short exercises as part of regular recitation periods, and watch for opportunities to make a few half-day excursions during the year. Streams, gorges, quarries, gravel-beds, and other instructive natural features will be at hand. Let the teacher have no anxiety as to correct methods of field teaching, but learn as much as possible about his neighborhood, and impart his knowledge and interest as best he may. Mistakes will be made, but they will be corrected by experience, and effective methods will develop. Have the pupils find out as much as they can, then talk over what has been seen, correct their mistakes, supply omissions, and have them record what they see in note-books. Refer to the excursions, in the class-room, where some points can be brought out more fully with map and blackboard, and the relations will be better understood, since time will have been had for reflection. The text will be saved from bookish unreality and the way prepared for better first-hand observations during future excursions. Great care

should be used in all arrangements for excursions, as to cost if transportation is involved, and as to safety if dangerous places are visited. One teacher should not try to handle a large class; and what may seem unnecessary caution should be taken, for the venturesome and unwary who will be found in every large class. Field teaching is laborious, but fruitful.

Certain of the recitation periods may be set apart for practical work. If possible, two consecutive periods will give better results than single periods in different days.

Outlines of field-work for several large centers will be found in *Suggestions to Teachers accompanying Brigham's Text-Book of Geology*. Many of these are equally useful for geography. The cities named are Boston, Providence, Springfield, New York, Albany and Troy, Buffalo, Philadelphia, Pittsburg, Baltimore, Louisville, Cincinnati, Cleveland, Indianapolis, Detroit, Chicago, Milwaukee, Minneapolis, and St. Paul.

Relation of the Study to the School Course

The text is primarily designed for use in the first or second high-school year, and in no case presupposes preliminary work in physics or other branches of science. If supplemented by suitable laboratory exercises, a full year course is needed for the accomplishment of the work. Such laboratory work, recorded in note-books, now constitutes part of the requirement in geography as established by the College Entrance Examination Board. Where, for lack of available time in the curriculum or absence of suitable equipment, formal laboratory exercises are impossible, the text may be covered in a half-year.

The reasons for the order of topics in the text are briefly set forth in the authors' preface. Under special circumstances a departure from this order may be made. In warm climates, winter field excursions can be arranged,

and there is less objection than in the North to placing the atmosphere early. Some schools are close to the sea border, and shore features are so familiar and are historically and commercially so important, as to make it desirable to introduce some work on the ocean early in the course. In such cases the decision rests with the intelligent judgment of the teacher.

SPECIAL SUGGESTIONS BY CHAPTERS

In the following pages helps for teaching single topics are given in sections corresponding to the chapters of the text. The suggestions include further explanations of points in the text, a list of special references, and outlines of laboratory and field exercises for each subject. It is not expected that any teacher or class can cover all of the exercises suggested, but that each teacher will select the most practicable in view of the home geography, and of the equipment of the school for indoor work. Nor is it expected that the teacher will give to the class all the supplementary explanations here made; they are rather furnished to the teacher in anticipation of various questions which may be asked.

At the end are given the pronunciations of a few words used in the text-book, mostly such as are unfamiliar or such as are often mispronounced.

Chapter I, The Earth

(Numbers refer to corresponding sections in Gilbert and Brigham's *Introduction to Physical Geography.*)

REFERENCES

Voyage of Magellan. *Discovery of America.* John Fiske.
Rocks, Rock-Weathering, and Soils. George P. Merrill.

SUPPLEMENTARY EXPLANATIONS

1. **The spherical figure of the earth** is best appreciated by the aid of a globe, and the globe is, for various reasons, the most important single piece of apparatus for geo-

graphic study. Have the scholars trace the route of Magellan's expedition from Spain to the Canaries, Brazil, the Straits of Magellan, the Ladrones, Samar, Luzon, Borneo, and back to Spain by the Cape of Good Hope.

2. **Latitude and longitude.**—The meridian of a point is the imaginary line running north and south through it and ending in the poles. As each point has a meridian the number of meridians is infinite. Similarly the number of parallels is infinite. The number which shall be represented on a map is determined by considerations of convenience and utility. They are usually omitted altogether when small areas are represented (Figs. 44 and 46). When large areas are represented on a small scale the interval from line to line is many degrees. Thus in Fig. 170 it is 40°; in Fig. 6, 20°; in Fig. 49, 10°; in Fig. 189, 5°. In the maps of States contained in ordinary atlases it is 1° or 2°; in some of the atlas sheets of the United States Geological Survey, as little as 5′.

How latitude is determined.—To understand this, it is necessary to consider the apparent motions of the stars. Because the earth turns on its axis, the stars seem to move through the sky. To us who live in the northern hemisphere the more southerly stars appear to rise in the east, describe arcs in the heavens, and set in the west. Each star moves at a uniform rate from rising to setting and is highest midway in its course. At the middle point it is said to cross the meridian. Some of the more northerly stars do not set, but have circular courses, and all these circles have the same center, called the north pole of the sky. If the axis of the earth be infinitely prolonged, it meets the sky in the sky pole. From a position on the equator, latitude 0°, the pole of the sky appears on the horizon. From a position on the pole of the earth, latitude 90°, the pole of the sky would appear in the zenith, or 90° above the horizon. And at any intermediate place

the latitude of the place is represented in degrees by the height of the sky pole above the horizon. Methods of determining latitude are therefore methods of measuring the angular height of the sky pole. The pole itself is not a visible object, but the distances from it of many stars have been carefully measured, and the geographer needs only to measure the height of some recorded star at the moment of its crossing the meridian, and make the proper allowance. Or he may use the sun's height at noon; its polar distance changes from day to day, but is carefully computed in advance for this very purpose, and is recorded for all parts of the year in a Government publication called the *Nautical Almanac.*

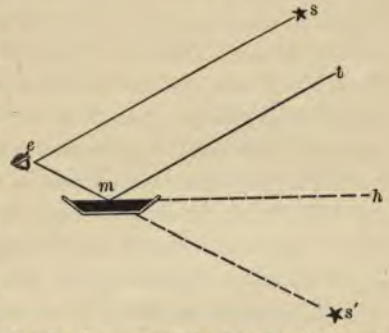


FIG. 1.—Geometry of the "artificial horizon" used in measuring the angular height of a star.

At sea, the base line or zero of measurement is the visible horizon of water. On land, where the visible horizon is uneven and can not be used, advantage is taken of the fact that the image of a distant object seen by reflection from a liquid surface, appears just as far below the horizontal plane as the same object seen directly appears above it. The angular height of star or sun above its reflection in a pan of mercury is measured, and the result halved. This principle will be understood by reference to the diagram.

A ray from the star, *se*, reaches the eye or surveying instrument at *e*. A parallel ray reaches a surface of liquid mercury at *m* and is reflected (with equal angle) to *e*, where it seems to come from *s'*. The angle *ses'* equals the angle *tms'*, and is double the desired angle, *tmh*.

How longitude is determined.—The original determination of the longitude of a place is always the measurement of the difference in longitude between that place and some other, of which the longitude is already known. Let us call the more easterly place A and the other B. As the earth turns from west to east the stars seem to pass around it from east to west. In this apparent journey, they cover 360° of longitude in twenty-four hours (of astronomical time), 15° in one hour, 1° in four minutes. In order to learn the difference in longitude between A and B, the geographer measures the time occupied by a star in passing from the meridian of A to the meridian of B. For this measurement, it is necessary to learn the moment at which it passes each meridian, but this is not observed directly. As the star rises toward the meridian, the moment when it reaches a certain height is noted, and afterward, as it descends, the moment is noted when it has again the same height; midway between the two is the moment of passing the meridian.

To secure precision, it is necessary to use the same time standard at the two places. If possible, they are connected by telegraph, so that instantaneous time signals can be sent. Otherwise, the most accurate kind of chronometer is carried from one place to the other.

Length of a degree.—Theoretically, the difference in latitude of two points on the same meridian is the angle in which vertical lines at those points, if extended downward, meet. The distance of this meeting point, called the radius of curvature, is greater for the polar region, where the curve of the surface is a little flatter, than for the region of the equator. The length of a degree is proportional to the corresponding radius of curvature. Degrees of longitude, on the contrary, diminish from equator to pole, the change being at first slow and then rapid.

Lengths of Degrees in Different Latitudes

Length of one degree of latitude (miles).	Latitude.	Length of one degree of longitude (miles).
68.7039	0°	69.1721
68.7250	10	68.1282
68.7856	20	65.0262
68.8787	30	59.9556
68.9931	40	53.0632
69.1153	50	44.5516
69.2304	60	34.6742
69.3245	70	23.7292
69.3860	80	12.0512
69.4074	90	0

3. **Earth temperatures.**—In a boring at Wheeling, W. Va., the rock at a depth of 4,460 feet was found to have a temperature of 110°, while near the surface the temperature was 51°. In the deep workings on the Comstock lode, Virginia City, Nev., the rock at 1,900 feet depth had a temperature of 130°, and water which came into the mine and had to be pumped out, ranged up to 157°.

Ice melts at 32°; potassium at 144°; sodium at 204°; lead at 850°; copper at 1,931°; and iron at 2,912°.

Density of the earth.—The average density of the rocks of the crust is about 2.7; that is, they weigh 2.7 times as much as the same volume of water. The mean density of the whole earth is 5.6. As the crust is less dense than the mean, some of the inner parts must be more dense, to bring up the average, and the density of the central part is probably as high as 10. This may be compared to the density of iron, 8, and lead, 11.4. There may be much iron inside the earth, or the interior may consist of ordinary rocks squeezed into less space by the enormous pressure to which they are subject.

4. **Crystalline rocks.**—Each mineral is a definite chemical compound, capable of forming crystals of some regular geometric form. Rocks are composed of minerals.

Usually the component minerals are in separate grains, either crystals or fragments of crystals. In igneous rocks, the crystals form themselves as the rock slowly cools and are usually of such size as to be readily visible. Such rocks are therefore called *crystalline.* Sedimentary rocks usually contain only fragments of crystals, the mineral grains having been derived from the breaking up of igneous rocks and the crystals more or less broken and worn in the process of change.

Words.—*Latitude* and *longitude* were introduced while yet geographers supposed the earth to be flat, and at a time when the known part of the earth had a greater extent east and west than north and south. Latitude means *width,* and longitude *length.*

Section, a cutting, is much used in geology and geography to indicate that which is seen when a part of the earth's crust is exposed by an opening. The wear of a creek gives a *natural section* (Fig. 3); an excavation for a railway, an *artificial section.* A drawing to represent what might be seen if a cutting were made is an *ideal section* (Fig. 2).

LABORATORY EXERCISES

1. **Curvature of the earth.**—If the school is near the sea or one of the Great Lakes, the phenomenon illustrated by Fig. 1 should be observed. The effect is most striking when one stands close to the water, but it is instructive to go afterward to a high point on a hill or tall building.

If an eclipse of the moon is to be visible, explain in advance what causes it, and that the edge of the earth's shadow will be curved because the whole shadow is circular. Bringing the class together in the evening, the full moon can be represented by a white disk on the wall, all lights but one put out, and the disk eclipsed by the shadow of a school globe or other spherical object.

2. **Latitude and longitude.**—Students should be so drilled in the use of the latitude and longitude lines of maps and globes that they can readily (1) tell the latitude and longitude of an indicated place; and (2) find a point of which the latitude and longitude are given. When these exercises are familiar, such problems as the following may be given: Which is farther north, New York or San Francisco, and how much? Which is farther east, Montreal or Quito, and how much? What is antipodal to Ohio?

Some of these exercises should be so chosen that the student must *interpolate* between meridians or parallels marked on the globe or map. There are many ways of

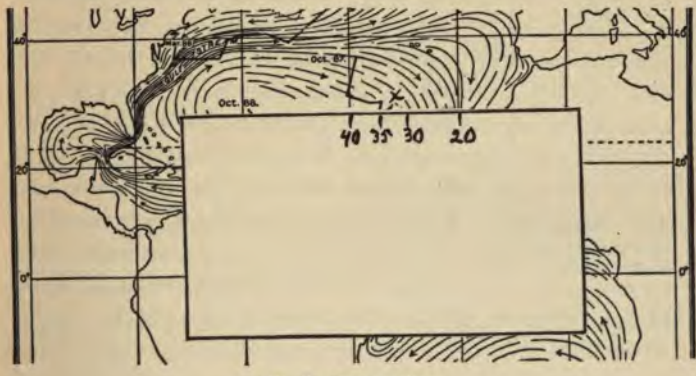


FIG. 2.—Interpolation.

doing this. A way which well illustrates the principle of interpolation is to actually draw intermediate lines. Suppose the problem is to determine the most easterly longitude in which the derelict Telemach was seen, from its track shown in Fig. 201. To avoid defacing the book, a piece of paper (Fig. 2) is so laid on the map that its edge is near the point x, to be determined. The positions of the meridians of 20° and 40° W. are marked on the paper.

Midway between them a line is placed to represent the meridian of 30°; and a line for 35° is placed midway between the lines for 30° and 40°. The point x is between the 30° and 40° marks, but nearer to the latter, and it is evident that if the lines for individual degrees were also made, the one for 33° would fall nearer than any other to x. The principle of interpolation will find other illustration in connection with thermometry and weather maps.

A rough measurement of the latitude may be made in the schoolroom, if it has a south window, at the time of either equinox (say March 21 or September 23). The sun at noon is then 90° from the pole of the heavens, and the angle between the sun's direction and the vertical line equals the latitude. Hang a plumb-line close to the window; mark the point directly below it on the floor (B); call that the base point; attach a button a half-inch wide at A, 100 (measured) inches above the floor (if the window is too low, substitute 50 inches and make allowance in the computation). Draw a line on the floor northward from the base point. If the direction of true north is not known, find it by means of a compass and the declination, as shown by Fig. 189, or else find it (on a previous day) by the principle that the shadow of the button is nearest the base point when directly north from it. On the day of the equinox, when the shadow is on the north line, mark its position (C) and measure in inches the distance to the base point. This measurement enables the latitude to be computed by the formula: Tangent of latitude $= \frac{CB}{100}$; but as the trigonometric tables may not be convenient, we give a table showing the values of CB corresponding to each fifth degree of latitude.

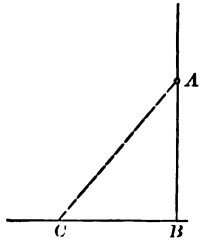


FIG. 3.—Diagram illustrating the determination of latitude.

Latitude.	CB.	Latitude.	CB.
0°	0.0 inches.	50°	119.2 inches.
5	8.7 "	55	142.8 "
10	17.6 "	60	173.2 "
15	26.8 "	65	214.5 "
20	36.4 "	70	274.7 "
25	46.6 "	75	373.2 "
30	57.7 "	80	567.1 "
35	70.0 "	85	1,143.0 "
40	83.9 "	90	Infinite.
45	100.0 "		

13. **Maps.**—Study Figs. 9, 10, and 11. This section does not explain modes of projection (see Sec. 217), but of showing relief. Have the student find highest altitudes and steepest slopes in 9 and 11. Superiority of 11 in information as to altitude. Fuller study of 11. Scale and contour interval. Kinds of culture lines on this map. Flat upland (prairie) and flat lowland (the river plain). Difference in altitude. Highest and lowest points in area. Let the student draw north and south profile across upland and river through La Salle. Use same horizontal scale as in map. Vertical scale, $\frac{1}{8}$ inch = 100 feet. Further practise could be had by representing this area in hachures, omitting the minor features, showing only main valleys. Other exercises on contoured maps will be given in connection with later chapters.

Chapter II, The Earth and the Sun

References

The Sun. C. A. Young.
Popular Astronomy. S. Newcomb.
The Earth's Beginning. Sir R. Ball. D. Appleton and Company.
The Earth's Shape and Size. Schott. *National Geographic Magazine,* xii, '01, 36.

SUPPLEMENTARY EXPLANATIONS

17–18. **Day and year.**—The earth turns on its axis about 366¼ times while making one revolution about the sun. The stars, therefore, apparently pass about the earth 366¼ times in a year. The motion of the earth about the sun makes the apparent motion of the sun slightly different from that of the stars; the sun apparently circles the earth only 365¼ times. A day, being determined by the alternation of light and darkness, is the time from one passage of the sun to the next, and is a little greater than the rotation period. It is the day which we divide into hours, not the rotation period. The earth makes a complete turn on its axis in 23 hours, 56 minutes, 04.1 second.

19. **Remoteness of the pole-star.**—Astronomers observe the direction of a star (*C* or *D*) when the earth is

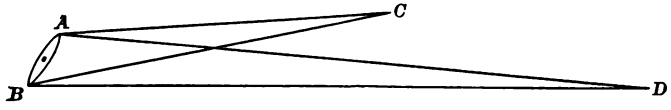


FIG. 4.—Diagram illustrating the measurement of the distance from the earth's orbit, *A B*, to a star.

at *A* in its orbit, and again six months later when it is at *B*. From the difference of direction (the angle *ACB* or *ADB*) the distance of the star is computed. The less the angle, the greater the distance. Only a few stars are near enough to have their distances measured in this way. The pole-star is so distant that the two directions seem the same.

21. **Irregularity of the orbital dates.**—If the number of days in a complete revolution of the earth were a whole number, without fraction, the dates of the solstices and equinoxes would be the same in all years. As it is, the dates vary slightly. The dates in Sec. 21 and the accom-

panying figures are correct for the year 1902. In 1903, the vernal equinox and summer solstice have the same dates as in 1902, but the autumnal equinox falls on September 24 instead of September 23, and the winter solstice on December 23 instead of December 22.

24. **Standard time.**—In actual practice, the standard-time districts are not bounded by meridians. It is not convenient for railroads to change their time at the points of crossing standard meridians; they change instead at the ends of divisions; and each town, as a rule, adopts the time used at the nearest railway station. The boundaries of districts are thus made irregular.

There are a few cities and small regions in the United States in which local time is still adhered to, despite its many inconveniences.

LABORATORY EXERCISES

18. **Draw an ellipse** 8 inches long and 5 inches wide. To do this, lay off two lines, *AB* and *CD*, representing the length and width, so that they cross at right angles and at the middle of each. With *C* as a center and with a radius of 4 inches (half of *AB*) draw an arc intersecting *AB* in *E* and *F*. These points are the foci of the ellipse.

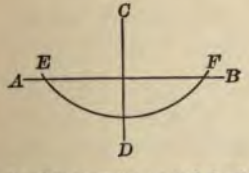


FIG. 5.—Construction to find the foci of an ellipse when the major and minor axes are given.

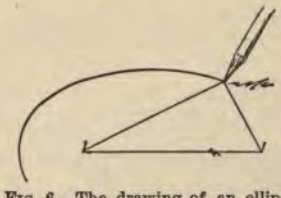


FIG. 6.—The drawing of an ellipse with the aid of a loop.

Set a pin at each. Make a loop of string just long enough so that when passed about the two pins it can be drawn out to *C* or *A*. Place a pencil inside and, pressing out-

ward to keep the string taut, draw with it a curve. The curve is the desired ellipse. Draw ellipses of other forms.

Draw an ellipse of the form of the earth's orbit. For this the length of the string should be 61 times as great as the distance between the foci. Draw a circle about one of the foci, and observe how little the two curves differ.

21. **Seasons.**—On a broad table (or on a broad sheet of paper lying on a table) represent the earth's orbit by a circle with a radius of 3 feet. A marble one-third inch in diameter may be placed at the center to represent the sun on the same scale. An ordinary grain of table salt is too large to represent the earth.

Mark twelve equidistant points on the circle to represent positions of the earth in different months, and label them as in Fig. 16. Now place a lamp in the center to represent the sun as a source of light, and represent the earth by a small globe with a stand. Have the flame at the height of the middle of the globe. First place the globe at the winter solstice (December 22) and incline its upper (north) pole away from the sun, with the axis at an angle of $23\frac{1}{2}°$. Note the part of the room toward which the axis inclines. Keeping the axis always parallel to its original position, move the globe to different parts of the orbit in succession and study the distribution of light on the globe. Turn the globe on its axis and observe the phenomena of long and short days in different latitudes. Follow all the explanations of the section.

FIG. 7.—Arrangement of lamp and globe to illustrate the cause of the seasons.

24. **Give problems in time.**—One hour difference in local time corresponding to 15° difference in longi-

tude; what time difference corresponds to 1°; to 1′; to 1″? What is the difference in local time between points differing in longitude by 22° 10′ 15″? What is the difference in local time between Portland, Me., and Portland, Ore.? What is the difference in standard time? What is the difference in longitude of two places differing 17 minutes 43 seconds in local time? The longitude of Washington is 77° 00′ 33.5″ W.; is the local time faster or slower than standard time (Eastern district), and how much? How does local time differ from standard time at Indianapolis? In San Francisco, local time is ten minutes slower than standard time (Pacific); what is the longitude of San Francisco?

Draw an outline map of the United States, showing standard-time belts.

Chapter III, Rivers

References

Rivers of North America. I. C. Russell. G. P. Putnam's Sons.

Chapters on Rivers in the *Physical Geographies* of Tarr, Davis, and Dryer, and in Brigham's *Text-Book of Geology.*

Rivers and Valleys in *Aspects of the Earth.* N. S. Shaler.

The Flood Plains of Rivers. W J McGee. *Forum,* vol. xi, 221.

Niagara Falls and their History, in *Physiography of the United States.* G. K. Gilbert. American Book Co.

Niagara Falls. A. W. Grabau, New York State Museum.

Exploration of the Colorado River. J. W. Powell. Government Report, out of print; in libraries and second-hand bookstores.

The Great Deltas. Lyell. *Principles of Geology,* eleventh edition, vol. i, pp. 412–489. (Also consult encyclopedia, articles *Rhone, Po, Nile, Rhine, Ganges, Mississippi.*)

SUPPLEMENTARY SUGGESTIONS

Words.—Different parts of our country were settled by people speaking different languages, and traces of those languages survive not only in the names of towns, rivers, etc., but in the words designating topographic features. Thus the Dutch introduced *clove* (ravine), *kill* (creek), and *vlei* (wet meadow), which are still heard in parts of New York. The French explorers gave us a group of terms, of which *portage* (carrying place) is known only near the Canadian border, *coulée* (dry stream-bed or gorge) from the Dakotas to Washington, *butte* (a steep-sided hill) west of the Mississippi, and *bayou* (distributary) along the lower Mississippi and about the Gulf coast. The use of *prairie* has become general. The Spanish, having a language rich in topographic terms, contributed several to the vernacular of the States which border Mexico. Among these are *arroyo* (small stream bed), *mesa* (bench, or small plateau), *cienaga* (springy place on a dry plain), *malpais* (lava-bed), and *playa* (alkali flat). *Canyon* (spelled *cañon* in Spanish) has spread through all the region west of the Mississippi. *Sierra* (mountain range), *rio* (river), and *agua* (spring) are preserved in proper names, as Sierra Nevada, Rio Grande, Agua Caliente.

Glen, which in Scotland designates a high-sided open valley, or glacial U-trough, is attached in the United States, and especially in western New York, to narrow gorges.

Delta is the name of the Greek letter Δ, and was applied to alluvial plains at the mouths of rivers because they are often triangular.

In Great Britain the boundary between two river basins is usually called a *watershed,* a word also applied sometimes to a river basin. *Water-parting* is also used. In the

United States the word *divide,* which at first had only colloquial use, has been adopted by geographers. *Height of land* is sometimes used in Canada.

LABORATORY EXERCISES

Many exercises are here offered. Teachers should select available exercises, basing the choice on the equipment and the surroundings. For the field trips, the note-book is the essential thing. Illustrate with profiles and sections. Perspective drawing is not necessary. If a half-dozen of the exercises on rivers are thoroughly done, a good beginning has been made. The directions to teachers in this chapter are given with especial fulness, and may serve as a general guide to the more briefly outlined work of succeeding chapters on the lands.

27. **Field study of a gorge.**—General geographic relations. Length. Depth. Find depth by estimate, as by comparison with trees, or with a man's height, or by using a line, if this can be done with safety. If the teacher has a hand-level and the slopes permit, get height of wall as follows: Stand at bottom, *a* (Fig. 8); sight to a point (*b*) on a level with the eye. Go up to *b* and repeat the process, and continue to the top. The number of sightings multiplied by your height to the eye, will be the height of the slope. This is a convenient means of ascertaining small altitudes in field-work. But practise the student in estimating heights and distances. If not vertical, ascertain the slope of the gorge wall, as follows: Paste a paper protractor into the

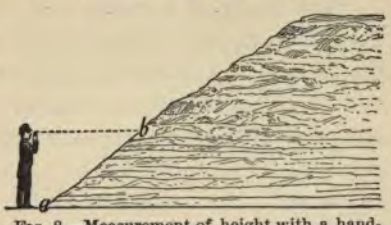
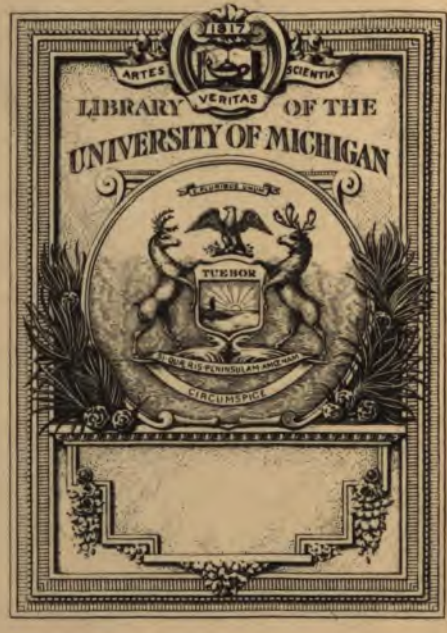


FIG. 8.—Measurement of height with a hand-level.


1817
ARTES
SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
CIRCUMSPICE

inside of the note-book cover as in Fig. 9, with the diameter parallel to the edge of the cover. Suspend a bob *b* from the center *c*. Hold the book so that the edge of the cover falls in line with the slope. The angular distance of the bob from zero will be the amount of the slope.

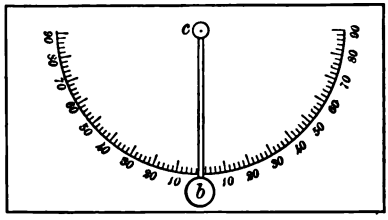


FIG. 9.—Simple clinometer or slope-measurer.

Study all features of the gorge—material of walls, as rock or drift; work of trees and other plants; effect of joints and planes of bedding; the talus or waste slope; the volume of water; the bed of the stream, whether on rock or rock covered by waste; character of waste in stream-bed, large, small, rounded, angular. (Consider streams with less or more than full load.) Draw cross profile of gorge, with data already learned.

Map study of a gorge.—Kaibab Sheet, Arizona. See Davis, King, and Collie, p. 16, for description. Locate the sheet on a general map and note contour interval and horizontal scale, as in study of all such sheets. Have student construct profile on north and south line, through the L of "Colorado River." This is a simple profile and shows well the inner and outer gorges. Use horizontal scale of map, and vertical scale, $\frac{1}{8}$ inch = 1,000 feet. Supplement this work with any available material on the Colorado plateau, and the canyon as a whole. Similar studies may be made of other gorges, as maps may be at hand.

Dynamic study of a gorge.—If a hose and a bank of earth are available, gorge-making can be shown in considerable detail. Note the crumbling of the earth, the formation of walls, the occurrence of rapids where a stone

is encountered in the down-cutting, and the gradual widening. A sprinkling-pot used on a sand pile will give good illustrations. If a basement in the school building is available, a tank may be fitted up in which a variety of such experiments may be conducted. Some of these will be suggested in later pages.

The tank should be 5 to 8 feet each way, as may be convenient. It may be zinc-lined. It should be arranged for discharge of the waste water at various levels, easily adjustable. A light jet or fine spray, as may be needed, must be arranged, as a full head, with the earthy material available, is too powerful for the best imitations of nature.

28. **Transportation by streams.**—Observation of this will often be combined with the field study of the gorge. Study size and form of material carried in the gorge and in more gentle reaches below. Note the size of rocks moved in flood-time; the darkening of water after a shower. Collect samples of river water before and after a storm and allow the material to settle. Estimate the daily discharge of a local stream and the amount of waste carried. Cast a handful of earth into a glass jar and let it be watched at intervals with study of the arrangement of the sediments after the water has become clear.

31. **Map study of divides.**—On any map of New York trace the line of parting between the Great Lakes system of waters, on one hand, and the Mississippi, Susquehanna, and Hudson on the other; around the head waters of the Genesee in Pennsylvania, south of the Finger Lakes, and northeast by Rome and through the Adirondacks—such are some of the directions. Study the divide locally on any atlas sheets, as—

(*a*) Elmira, where the parting is faint, north of Horseheads. This sheet will be useful in studies of the glacial lakes, since this was an important overflow point.

(*b*) The Oriskany sheet, in which Rome stands on a

mile of flat ground separating the Mohawk from Wood Creek, whose waters flow to Lake Ontario. This was a "carrying place" in colonial days, and marks the divide along whose easy grades the vast traffic of the present day proceeds.

Sharp crest lines or mountainous lines of water-parting should be observed on any available maps, so that divides in their great variety may be known to the student.

32. **Waterfalls.**—These are so diverse in origin that a single example is scarcely enough. Any local waterfall should be carefully studied. Find its origin in the conditions of the rocks. If it has a hard-bed crest, the problem is simple. Note height, width, and any evidences of past or present recession. Many falls will be found to depend, not so much on alternation of hard and soft layers, as upon vertical jointing, which causes regular recession, and preserves a vertical face.

Niagara may be well studied as the greatest American example. The text, with Figs. 24, 25, offers some material. Secure the Niagara Falls sheet. Study the Niagara plateau, the Niagara escarpment, and the Ontario plain. Study the gorge in detail and make profiles below the falls and along the whirlpool rapids. For other important features, consult Gilbert's *Niagara Falls*.

37–40. **Field study of flood-plains and meanders.**—Only general hints can be given, because local examples must be used. Note the width of flood-plain, its materials and stratification. Look for natural levees and surfaces sloping to the valley side. Consider the fertility of the soil, sites of houses or villages, and all human uses. Is the width of the plain in proportion to the size of the stream? Gather all possible data as to floods. The reason why the stream pursues a meandering course. The topography on the outside and inside of the bend. The depth of water in these situations. Increase in size of the

ox-bow bends; cut-offs, and how caused. Note the narrow swing of a brook and the wide swing of a great river. Bring out as many as possible of these principles from local streams.

Map study of flood-plains and meanders.—Enlarge the students' conception by a wider range of illustration such as may be had from maps. Examine all available atlas sheets for examples. The maps of the Lower Mississippi give countless cases. Davis, King, and Collie give (p. 33) Fort Payne, Ala.; St. Louis (east sheet), Independence, and Marshall, Mo.; Junction City, Kan. One map should be assigned to each student for full description of all flood-plain features shown. In this, as in other map exercises, let the student take the point of view of a bird's-eye observer of the region. Precise description thus becomes a discipline in seeing and in expression.

42. **Dynamic study of deltas.**—Shallow water in any available tank. Earth or sand to imitate land surfaces. Spray arranged as in Sec. 27, but now with reference to the deposit in the edge of the water. After the delta has been formed and its character identified in accordance with the text, draw the water down on the frontal slopes of the delta and watch the dissection and the formation of the new delta at a lower level. Produce different effect by using spray of different capacity and land materials of different degrees of coarseness, as gravel and sand in one instance, and clay in another.

Library study of any great delta, as the Nile or Ganges.—Let the student read and report on references as previously given, and construct an outline map of the distributaries and shore line.

48. **Map study of lake filling.**—Fig. 42 may be used. Still better, the entire Watkins sheet, if at hand. The length and width of the delta on which Watkins and Mon-

tour Falls are, should be noted, and the sources of supply in the cutting of Watkins and other gorges. A general study of the topography should be included, and a profile across the valley constructed. Observe Salt Point on the west. Local ponds and small lakes are likely to afford parallel and actual examples. If there are borings in the delta, or soundings of the lake, interesting use may be made of such data. Thus the cubical contents of the fill may be estimated.

45–50. **Comparative study of maps, Fig. 41 and Fig. 44.—Mature and imperfect dissection by stream.**—Compare the two areas as to their general character—their altitude; their nearness to the sea, and the hardness of the rocks. In the West Virginia area the land is high, far from the sea, and composed of old and hard rocks. In all these respects the Potomac River district is its opposite. One is old land, and the other is new. One is coursed by streams; the other has few streams and wide inter-stream belts. In one the roads run by the streams; in the other, on the uplands. The older, harder country is the more dissected. Hence, the youth of the other area is emphasized; for though it is easy to carve, the streams have not yet accomplished much work upon it.

51. **Trellised, or rectangular drainage.**—Monterey sheet, Virginia and West Virginia; Pine Grove sheet, Pennsylvania. Let the Monterey sheet be first studied. The chief streams are longitudinal, and the mountain ridges lying between are more or less completely cut into sections by the small transverse streams. See Thorny Creek Mountain, Thomas Mountain, etc. Compare Pine Grove sheet. Swatara Creek is the chief stream, and it shifts from transverse to longitudinal several times below Tremont. Have parts of the drainage of either sheet traced, making a sharp effect by thus removing the other lines of the map. Harrisburg sheet may be compared

for a transverse stream of vast relative size. And all should be compared with maps showing the more common tree-like drainage.

54–62. An elementary but useful supplementary exercise is to reproduce on a skeleton map the chief river systems and draw in the lines of water-parting.

55. **The Mississippi River.**—Study the river system by all available maps and literature. Few specific directions can here be given. Do not try to study all parts thoroughly. Select those for which maps or other helps are available. On the Great Plains, study the Platte and Missouri intensively. In Louisiana, give exhaustive attention to the delta. If the maps of the Mississippi River Commission are available, all students should examine, and describe in their note-books in full detail, one or more of the large sheets which show meanders, cut-off lakes, types of vegetation, and other features. Location of cities, navigation, levees, floods, and the jetties at the southern extremity of the delta, are fruitful topics for inquiry and record.

Detailed study of the nearest considerable stream.—Here the invention of the teacher must provide material. All possible maps should be secured. Of a stream of any importance the hydrographic volumes of the United States Geological Survey may give the amount of discharge. The form of the valley should be studied, and profiles made at different points if they can be visited. Flood-plains, terraces and all possible forms of waste and cliff should be examined and all human uses of the stream discussed and recorded.

CHAPTER IV, WEATHERING AND SOILS

REFERENCES

Rocks, Rock Weathering, and Soils. George P. Merrill. Macmillan. A specially valuable treatise for the library and the use of the teacher.

Origin and Nature of Soils. N. S. Shaler, in *Twelfth Annual Report, United States Geological Survey.*

Reports of the Division of Soils. United States Department of Agriculture. This is a recently established division, engaged in studying and mapping soils of the United States. Address inquiries as to such possible work in progress in your own region, and concerning reports, to Prof. Milton Whitney, Chief of the Division of Soils, Washington, D. C.

Artesian Wells. T. C. Chamberlin. Paper in *Fifth Annual Report, United States Geological Survey.*

Celebrated American Caverns. H. C. Hovey. Clarke, Cincinnati.

Mammoth Cave. H. C. Hovey. *Journal School Geography,* i, 133–139.

Stones for Building and Decoration. George P. Merrill. John Wiley & Sons.

Minerals and How to Study Them. Dana. John Wiley & Sons.

Common Rocks. W. O. Crosby.

Elementary Lithology. George H. Barton.

Various publications on State Resources—e. g., *Building Stones of New York.* By New York State Museum, Albany. 40 cents. *Building and Ornamental Stones of Wisconsin.* Buckley. And in many geological reports and popular volumes issued for expositions, etc. Consult State geologist, or some professor of geology, for specific information.

SUPPLEMENTARY EXPLANATIONS

64–67. **Pictures of rocks.**—Different rocks are differently affected by the weather, so that their cliffs and crags have different characters. When the eye has become ac-

quainted with these characters, the nature of a rock can often be told at a distance or from a photograph. Sandstones are shown in Figs. 17, 23, and 54; shales in Figs. 3, 21, 52, and 59; limestones in Figs. 3, 22, and 55; granite in Figs. 61, 98, and 109. In Fig. 64, all the greater ledges are of limestone, except the white ledge near the top, which is of sandstone. In the frontispiece the stratified rock resting on the granite is a sandstone—of which a nearer view appears in Fig. 54.

LABORATORY EXERCISES

In the following paragraphs, a few minerals largely composing sandstone and other common rocks are studied with those rocks. If preferred, they may be studied previously and in greater number. If specimens are at hand (and they are easily obtained of dealers) the other common minerals, as gypsum and those of iron, may be included, though not especially required for our text.

64. **Laboratory study of sandstone.**—Quartz, the prevailing mineral of a typical sandstone, should be examined as to hardness (penknife test), solubility (dilute hydrochloric acid), crystalline form and color. Under the last head, observe rock crystal, milky quartz, smoky quartz, amethyst; then take all available specimens of sandstone. Study them for color, size of grain, shape of grain, and cement. Crush a fragment for better observation of these points, using magnifier or low-power microscope. Study proportions of quartz and other materials. Test with acid for calcareous cement. Examine grains of a red sandstone for traces of iron oxid cement. In a non-glacial region, or among glacial drift fragments, find sandstones that are weathering into original constituent grains. Have at hand samples of coarse and fine sands from sea and lake shores and glacial deposits. Compare them with each other and with crushed sandstone.

Compare samples of conglomerate with ordinary sandstone. Have student make full record of all these observations. Many other points will be suggested to the teacher in the progress of such exercises.

65. **Study of shale.**—This is a less satisfactory subject for elementary examination than sandstone, as its fragmental character is less easily demonstrable. But the general appearance, color, and leaf-like bedding can be seen and compared in several specimens. As clay is the chief constituent of true shale, study samples of clays as they may be obtained from brick-yards, potteries, and natural exposures and bottoms of ponds. Some samples will show interesting gradations into sandstones. Have the student discriminate between shales and slates. The last are not introduced into the text. They are hardened, or, in some cases, baked shales, which split readily and are very durable, as roof slates and marking slates. Bring out the fact that shale rock is often ground for the making of various kinds of bricks.

66. **Limestone.**—Compare as to color and general appearance a number of samples. Note the great variety of color, if several specimens are available. Some are fine-grained and massive, while others are more or less full of crystalline faces or grains of calcium carbonate ($CaCO_3$). Test with the acid. The crushed rock will give most brisk effervescence. Allow the material to remain in the acid until all possible solution has taken place. The residue, if a sufficient quantity of acid is used, is of other minerals. Compare its amount with the original fragment. Study crystalline calcium carbonate, the mineral calcite. (*Dana's Minerals and How to Study Them,* pp. 247–254.) This may, if preferred, precede the examination of limestone. Marble may be compared with common limestone, being derived from it by pressure and other agencies, producing what geologists call metamorphism.

67. **Granite.**—This being one of the commonest rocks in monuments and the better class of buildings, a good knowledge of it adds much to the student's practical intelligence, and at the same time will help him to understand how the crystalline rocks are modified by weathering. For specimens, visit stone-yards or sites of granite buildings under construction. Some may be found having a weathered rim or film, and these are especially useful. The quartz will already have been studied. Let the feldspar be taken up for cleavage, colors, and hardness. Note that quartz will scratch feldspar, but that the latter is much harder than the calcite or calcium carbonate. The principal properties of mica should be studied, and the granite then examined for the three minerals. Sometimes the mica is replaced by hornblende. All the minerals of the granite may be coarse or fine, and may show such varying sizes and colors as to give all varieties of texture and color to the rock. In some places, a tray of granite waste from natural weathering may be obtained and compared with the rock.

68–76. **Field study of weathering.—Buildings and monuments.**—This is an especially useful exercise in cities, in which field-trips are often made with difficulty. If class excursions can not be made, individuals can at least be directed in observations upon stone structures. Let the monuments of a cemetery be studied, and notes made, giving their dates and appearance; loss of polish, discoloration; accumulation of lichenous growths, flaking and splitting. Similar effects will appear in buildings. Not many blocks of brownstone fronts will have been traversed before conspicuous instances will be found. Bedding planes will come to light and blocks here and there will show signs of early and complete destruction. Let the students' notes show these facts, with precise location and descriptive details. Discoloration may be detected, either

in streaks or in a general change of tone, as where two buildings of the same stone differ twenty years in their time of erection.

Field study of weathering.—Natural ledges, quarries, and the drift.—Here a great variety of examples may be found in almost any region. The suggestions of the text are a sufficient guide as to the kind of results to be looked for. The oxidation and discoloration of the upper layers in sand-pits, excavations for cellars, and railway cuts, are among the most common and instructive. The same are seen in quarries, and here solution will often show conspicuous results in opening channels along the joint planes. The talus slopes at the base of cliffs and the crumbled appearance of ledges of shaly rock are also common facts, and the work of tree roots can almost always be seen along steep, rocky banks.

77. **Thickness of land waste.**—This affords a profitable study. It should be remembered that in the glacial belt some of this waste is not due to weathering, but the study can be carried on with this in mind. How thick is the earthy cover of quarry rock, and how deep must wells be sunk in any region to meet bed-rock? The average thickness of the earthy cover in a region affords a good problem, though estimates will always be general and uncertain. A class of students will be able to bring interesting results together, in a rural community at least, by inquiry as to the depth of wells and the kind of material encountered in digging or boring them.

77–79. **Collections of samples of soil and drift.**—This work is profitable to the student and may be utilized for the school equipment. All the sands of various coarseness and color, including gravel; the clays and the various soils and subsoils should be gathered. Soils from sandy ground, from clayey districts and from swampy, or low areas and forests, should be sought. Let them be ex-

amined as to texture and color, and a suitable quantity of each be placed in a bottle with label, giving its precise locality. The bottle should be wide-necked and 3 to 5 inches in height.

89. **Water in rocks.**—Let a water-soaked rock be weighed, and then thoroughly dried, and again weighed, noting the amount of loss; or take a dry sample from the collection, weigh it and then let it soak for twenty-four hours or longer, and weigh again. Compute the percentage of loss or gain; do this for different kinds of rock, and thus compare their capacities for absorption.

Chapter V, Wind Work

REFERENCES

Dust and Sand Storms in the West. J. A. Udden. *Popular Science Monthly,* vol. xlix, 1886, pp. 655–664.

Sand-binding Grasses. Yearbook, Department of Agriculture, 1898, pp. 405–420.

Text-Book of Geology. Brigham. Chapter i.

Man and Nature. G. P. Marsh. Chapter v treats of drifting sand.

Cape Cod. H. D. Thoreau. Various editions. Several passages on the moving sands of the Cape.

Historical Geography of Palestine. Smith. *Land and Book.* Thomson. And other works on the Holy Land, for references to ravages of sand along the Mediterranean coast.

Earth Sculpture. J. Geikie. Chapter xii, pp. 250–265. Putnam.

LABORATORY EXERCISES

108–119. **Field study of blown sand.**—Specific directions can not be given. In regions of moisture and abundant vegetation, little opportunity is offered. The more sandy glacial deposits are sometimes incoherent enough to be subject to wind action, being too barren to nourish a plant cover. Dust blown from roadways and plowed

fields may be the only example accessible to many. Along the Atlantic seacoast, however, as on the borders of the Great Lakes and in much of the territory west of the Mississippi River, dune sands can be made subjects of actual observation. The forms should be studied, and, if possible, sketched or photographed. Points to be observed: Arrangement, whether in hummocks or wave-like ridges; height; angle of slope of surface; relation of forms to prevailing winds; migration of sands now in progress; strength of wind needed to move the material; rippled surface due to winds, if present; vegetation on the dunes; invasion of cultivated land by dunes; efforts to prevent such invasion.

112. **Map study of dunes on the Great Plains; Kinsley sheet, Kansas.**—Make a general study of the map, position of area in the State, relation to Arkansas River, noting scale and contour interval. Dune forms southeast of Arkansas River and along middle of area from east to west. Dunes east of river, but not west, by reason of prevailing winds. Forms of dune hills, altitudes, and number of hills on a given area, as on a plot two, three, or four miles square. Contrast between the dune areas and the erosion topography on the south and the northwest. Find small dune patches also on Meade, Dodge, and Coldwater sheets, Kansas. Compare the Kearney sheet, Nebraska. Here we have a similar relation to an important river, with dunes on the south, and erosion forms on the north. The belt of dunes is narrow, being two to four miles wide. Observe the "braiding" of the Platte, showing the shifting of its streams and the extent of alluvial ground from which the sands are derived. Have the student record all these points. Bring them out by careful questioning rather than by direct information.

120. **The sand blast.**—It will be possible in many large towns and cities to find this in operation. Pupils who

are able to observe it will readily understand the work of the natural sand blast. The following list of uses of the sand blast (taken from the *Popular Science Monthly* for September, 1895) will give the teacher hints as to the kinds of establishments in which the blast is likely to be found. The list itself will, in any case, be useful in teaching:

Frosting and decorating glass.
Labeling of graduated measures.
Removing hard scale from castings and forgings.
Carvings and inscriptions in intaglio or relief, on stone, slate, and granite.
Delicate drawings for lithography.
Removing fur and deposits in tubs and tanks.
Cleaning off accumulations of paint and dirt within iron ships.
Decorating buttons.
Piercing the holes in glass ventilators.
Marking pottery and ornamental tiles.
Refacing grindstones and emery wheels.
Granulating celluloid films for photography.
Bringing out the grain of wood in relief, as sometimes for blocks used in printing.

Chapter VI, Glaciers

References

Chapters on *Glaciers and Glacial Period* in Tarr, Davis, and Dryer's text-books of Physical Geography, and in any text-books of Geology.
Glaciers of North America. I. C. Russell. Ginn.
Forms of Water. Tyndall. Appleton.
Ice Age in North America. Wright. Appleton.
Great Ice Age. Geikie. Third edition. Appleton. Chapter by Chamberlin on the *Ice Age in North America.*

Annual Reports United States Geological Survey. Those who have access to these volumes will find several papers of great value as follows:

Third Report, *Terminal Moraine of the Second Glacial Epoch.* Chamberlin.

Fifth Report, *Existing Glaciers in United States.* Russell.

Sixth Report, *Driftless Area of Upper Mississippi Valley.* Chamberlin and Salisbury.

Seventh Report, *Rock-scorings of the Great Ice Invasions.* Chamberlin.

Eleventh Report, *Pleistocene History of Northeast Iowa.* McGee.

Sixteenth Report, Part i, *Glacier Bay and its Glaciers,* Alaska. Reid.

Eighteenth Report, Part ii, *Glaciers of Mount Rainier.* Russell.

First Crossing of Greenland. Nansen. Longmans, Green & Co.

Northward Over the Great Ice. Peary. Frederick A. Stokes Co.

Glacial Studies in Greenland. Series of papers by T. C. Chamberlin, in *Journal of Geology* (University of Chicago), 1894–1897.

Short History of the Great Lakes. Taylor. In *Studies in Indiana Geography.* Edited by Dryer. Inland Publishing Co., Terre Haute, Ind.

Earth Sculpture. J. Geikie. Chapters x, xi. Treating land forms due to glacial action.

Glaciers of the Alps. Tyndall. Longmans, Green & Co.

Hours of Exercise in the Alps. Tyndall. Appleton.

Ice Work, Past and Present. Bonney. Appleton.

Illinois Glacial Lake. Leverett. Monograph XXXVIII. United States Geological Survey.

Glacial Lake Agassiz. Upham. Monograph XXV. United States Geological Survey.

SUPPLEMENTARY EXPLANATION

121. **Rate of flow of glaciers.**—The central parts of Alpine glaciers move forward from 100 to 400 feet a year, the sides more slowly. The motion in summer is twice

as rapid as in winter. The tongues of the Greenland ice sheet as they approach the sea, have sometimes a much greater speed; in three localities their summer rates have been found to be 32, 62, and 99 feet per day.

Words.—Early studies of glaciers were on the Swiss Alps, where the French language is spoken. So the chief technical terms are from the French. *Glace* (ice) is the root of *glacier*. *Crevasse* is crack. *Moraine,* related to *mur* (stone wall), refers to the ridge-like character of some medial moraines. Rock knobs, rounded as in Fig. 104, are called *moutonnée,* because a field of them suggested a flock of sheep. The Swedes, navigating northern seas, gave us *iceberg,* from *is* (ice) and *berg* (hill). English-speaking geologists have furnished most of the terms descriptive of the work of ancient ice-sheets. *Drumlin, esker,* and *kame* belong to the vernacular of Ireland. *Till* is supposed to be Scotch. *Drift,* meaning something moved along, has acquired two uses in geography: the waste transferred by ancient ice, and a slow current driven by the wind.

LABORATORY EXERCISES

121. **Intensive study of the Gorner glacier.**—Section 121 and the accompanying illustrations should be mastered and the map and view compared in detail. If other literature is accessible, yet more attention may be given. An account of Tyndall's crossing of the glacier and ascent of Monte Rosa is found in his *Glaciers of the Alps.* Baedeker's *Guide to Switzerland* should be consulted for the region about Zermatt, including the Gorner glacier and the Matterhorn, also works of Whymper and other Alpine travelers. See also Fig. 134.

122–124. **Study of photographic views of other Alpine or Cordilleran glaciers.**—The various pictures of glaciers in the text should have received careful attention in the students' daily lessons. A laboratory period can be profit-

ably given to the examination of other glacial views, all points of comparison being recorded in the note-books. Text-books, books of travel, and the actual photographs should be used. In this way a class or laboratory division can be supplied with material even without duplicates, and fresh subjects for study provided by exchange among the students. Several views are given in Brigham's *Text-Book of Geology.* Among these are the Viesch glacier (frontispiece), showing the windings of a long, narrow glacier between steep mountain walls and bearing belts of medial moraine. With this may be compared Fig. 47 of the same text-book, showing the point of formation of such a moraine and some of the upper snow-fields. Figs. 44, 48, 49, 50, 51, 52, 280, and 281 form an instructive series from the Aar glacier and Aar valley of Switzerland. Russell's *Glaciers of North America* and other references given above will afford views of North American ice streams. Diller's *Mount Shasta* in the National Geographic monographs gives an account of the five glaciers of that volcanic mountain. See also *A Young Volcanic Mountain,* and the Shasta special map, in *Physiographic Types,* folio i, Gannett, United States Geological Survey. Other materials for such comparative study will suggest themselves to the teacher.

125. **Intensive study of the Greenland ice-sheet.**— As this is the best known and the second in size of existing ice-sheets, its study will be usefully carried beyond the brief account in the text, if time permits. Wright's *Ice Age in North America* and Geikie's *Great Ice Age* have chapters on the Greenland ice. The works of Nansen, Peary, and other arctic explorers should be consulted as far as available. A valuable series of papers on the Greenland glaciers was published by Chamberlin in the *Journal of Geology* (University of Chicago), 1894–'97. See also *Greenland Icefields,* by G. F. Wright, Appleton.

Any two or three of the above references will afford material for a profitable exercise.

129. **Glacier motion.**—No discussion of theories is given in the text, and experiments are of little value, unless conducted with elaborate provision, such as is impossible in most schools. Blocks of asphalt or other pitchy substance may be exhibited, their brittleness shown with a hammer, and given sufficient time they will change form at ordinary temperature. A stick of sealing-wax may be supported by its ends and will in a short time be found to sag in the middle. Tyndall's experiment may be repeated by suspending a weight by a wire to a bar of ice, until the wire cuts through the bar, and the cut surfaces are reunited by freezing. The reconsolidated ice in the packing of an ice-cream freezer gives a very rough illustration of reconsolidation after fracture. With a screw and press interesting changes of form and consolidation of snow and ice can be accomplished. These exercises are suggestive, but the student must not be allowed to suppose that they explain glacier motion.

132. **Field study of till and erratic, or drift boulders.**—It is not here meant that a field excursion can often be limited to the observation of these glacial features. Other phenomena, such as are mentioned in the exercises that follow, will usually come in as a matter of convenience, but clearness will be promoted by grouping these suggestions to the teacher. Railway cuts, wells in process of digging, and all other available sections are to be sought. Note the absence of structure, the irregular attitude of the stones, the sizes of the latter and their abundance relative to the mass, their forms and surfaces, whether the till is interrupted by any stratified beds, its thickness, color, and any other features.

Drift boulders offer many subjects of inquiry, such as their size; their abundance, being often numerous in some

localities and few in fields near by; their source and the direction from which they must have come; their state of preservation, depending on the hardness of the rock and the distance through which they have traveled. Many other questions may be asked. Teachers may find aid as to method in a paper on *Drift Boulders between the Mohawk and Susquehanna Rivers,* by A. P. Brigham, *American Journal of Science,* 1895.

133. **Field study of glacial pebbles and striated bed-rocks.**—This subject is closely related to the last, since the scratched pebbles are commonly found in the till and the graven bed-rocks beneath it. The varying capacity of rocks to take and hold the scratches should be considered. From the shape of the pebbles or boulders, some judgment can be formed as to the amount of material they have lost by such grinding since broken from the parent ledge. The amount of rounding of the corners should be observed, the greater abrasion of sides as compared with ends, the usual parallelism of scratches with the major axis of the stone, and the numerous departures therefrom.

In studying the bed-rock scratches a small compass is necessary to ascertain their direction. In the northern United States it is usual to read and record the direction with reference to the south, because the ice is known to have moved more often in that general direction. Thus, S. 20° W., or S. 30° E., would be a proper record. If the scratches are upon an inclined surface, the amount and direction of greatest slope should be recorded and the surrounding topography adequately described. Chamberlin's paper on rock scorings should be studied by teachers whose location enables them to give their classes such observation.

134–141. **Field study of other glacial features.**—These are in such variety as to render precise directions impossible in this brief outline. The teacher must be guided by the material afforded by his locality. The washed

glacial materials and the level forms due to their deposit will often be the most conspicuous products of glaciation. Here all possible sections should be studied, with the stratification, coarseness or fineness of material, horizontality or inclination of the beds, and general forms, whether distinguished as kames, eskers, glacial terraces or deltas, or frontal aprons. The map and picture studies that follow will, in a measure, atone for the lack of these forms in many localities. Rounded or fluted, or benched rock hills, or the general topography of the uplands in a glaciated region, should be studied, as well as any lake basins that are attributable, as most of them are, to some form of glacial action.

134. **Kames and moraines in general.**—Map study. Eagle sheet, Wisconsin; Charleston sheet, Rhode Island; and Stonington sheet, Connecticut, Rhode Island, and New York.

Rough lands, irregularity of contour lines, lakes, kettles, and swamps are the features to be noted. For Eagle sheet, consult *Physiographic Types,* United States Geological Survey, folio i, Gannett. As this folio is inexpensive (25 cents) and should be in the hands of every teacher, details need not here be suggested. The remaining two sheets show the adjacent southern corners of Connecticut and Rhode Island. The moraine contours are conspicuous from Watch Hill to Point Judith Pond, along a narrow belt just back from the shore. Note the irregular contours and numerous ponds. Since the building of the moraine the sea has made a long, smooth barrier beach, inclosing ponds between itself and the moraine. See Davis, King, and Collie, p. 38.

135. **Eskers.**—These ridges are so irregular and often so low that the contoured maps fail to give any adequate idea of them. They are also not common and therefore are inaccessible to most schools. Some views will be

found in the text-books, but these again are fragmentary, because of the difficulty of bringing more than a short section of the ridge clearly within the photographic field. But good photographs of eskers will soon be more available than now and may be made the basis of a short exercise. If the teacher has access to libraries, the following should be consulted: *Some Typical Eskers of Southern New England,* by J. B. Woodworth; *Proceedings Boston Society of Natural History,* vol. xxvi, p. 197; and the *Origin of Eskers,* W. O. Crosby, *American Geologist,* vol. xxx, pp. 1–39, July, 1902.

136. **Map study of drumlins.**—These forms are so strong and simple that the maps give an exceptionally good expression of them. The Sun Prairie sheet, Wisconsin, is needed for this study. In addition to it, the Madison, Waterloo, Evansville, Stoughton, Watertown, Koshkonong, and Whitewater sheets, all of Wisconsin, may well be secured and mounted with the Sun Prairie in a group. Refer to Davis, King, and Collie, p. 37, and to *Physiographic Types,* folio i, United States Geological Survey. In the latter Sun Prairie is taken as the type. New York teachers, and indeed all, may well secure the maps of the great drumlin area south of Lake Ontario, and mount them also in a group. Seventeen sheets are required to take in the whole area, and most of these have been published, but two are not yet available. The Pultneyville, Sodus, Oswego, Fulton, Palmyra, Clyde, Weedsport, Baldwinsville, Phelps, Geneva, Auburn, and Skaneateles make a compact rectangle, to which the Macedon and Canandaigua can be added at the west and the Syracuse and Tully at the east. Whether the Wisconsin or New York area is studied, the points of inquiry are similar: the shape and height of the hills; their trend as showing direction of glacier movement; their variations in height, length, etc., as along Lake Ontario, and

on the southern border of the belt; the number on a given area; the interruption of drainage, the ponds and marshes due to their presence. The drumlins of Boston Harbor should be considered, especially by New England teachers, and all local examples, wherever found. What is the relation between drumlins and the drumlinoid hills of a glaciated region? The latter are often very high and massive, and are composed of the bed-rock, barely veneered with drift. The resemblance is therefore in form, the same agent working on different material.

141. **Map study of lakes, Plymouth sheet, Massachusetts.**—Many other sheets would serve as well and may be preferred for local character. If Plymouth is taken, note the relation of the area to the moraine belt of southern New England, and let the student observe the irregular form and distribution of the ponds and their great number. It is a simple but useful exercise to reckon the number of square miles of land surface in the quadrangle and count the ponds which it contains. Other sheets with many lakes may be compared so far as time permits. Fine examples are found in the Adirondacks, as the Paradox Lake sheet.

Chapter VII, Plains

References

Elementary Physical Geography. Davis. Pp. 141–162. Ginn.

Physical Geography of New Jersey. Salisbury. Vol. iv. Final reports, Geological Survey of New Jersey.

Coastal Plain of the Carolinas. See Cobb and Glenn, *Journal of School Geography,* vol. i, 256, 300, and ii, 9, 85.

For somewhat full accounts of the Chesapeake Bay and Fall Line region see papers by McGee in Seventh and Twelfth Annual Reports, United States Geological Survey.

The High Plains [east of the Rocky Mountains] *and their Utilization.* U. D. Johnson. Twenty-first Annual Report, United States Geological Survey, part iv.

Davis, King, and Collie. Use of Governmental maps in schools, pp. 10–15.

Old Virginia and her Neighbors. John Fiske. Many instructive references to influence of natural conditions in "tidewater Virginia."

Physiographic Regions of the United States. Powell. In *National Geographic Monographs,* now issued as *Physiography of the United States.* American Book Co.

LABORATORY EXERCISES

150. **Map study of the Atlantic coastal plain.**—Fig. 44 may serve for a beginning. An arm of the Chesapeake is at the northeast. All altitudes are small, roads run on the inter-stream areas instead of following the rivers. The streams are tree-like, for the beds of soft rock are nearly horizontal and do not guide the course of the waters. A most useful map for class or laboratory use is made by grouping several sheets embracing a large part of Chesapeake and its bordering lands and mounting them. It can then be described in some detail by the student, with note-book record. The sheets needed are Brandywine, Prince Frederick, Sharps Island, Wicomico, Leonardtown, Drum Point, Mt. Ross, Piney Point, and Point Lookout, all in Maryland. See also *A Coast Swamp,* Topographic Atlas United States, *Physiographic Types,* folio ii. The area named by Davis, King, and Collie as a type is that of the Glassboro sheet, New Jersey. See D., K., and C., p. 10, for suggestions. See also, for further hints on the study of this sheet and other parts of the Atlantic coastal plains, *Geography in the Horace Mann Schools,* Dodge and Kirchwey, *Teachers College Record,* March, 1901. Columbia University Press, Macmillan Co., agents. 20 cents.

152–155. **Map study of lake plains.**—The following sheets in the Niagara region: Niagara, Tonawanda, Lockport, Wilson, Olcott. The series may be continued eastward if desired. Show the old lake bottom (Iroquois, Sec. 144 and Fig. 112) with the Iroquois shore line; and south of the last, the Niagara escarpment, followed by the Niagara plateau. This low plateau, however, was flooded in an earlier and higher stage of the Great Lakes. We may thus truly regard the whole of these sheets, except for the escarpment and the Niagara Gorge, as representing lake plains. Note wide spacing of contours, sluggish streams, and any other features. The lacustrine soils and softer climate have made this a region of fruit and grain. In a similar way the Fargo sheet, showing part of the bottom of Lake Agassiz, should be studied (see p. 156). The Tooele Valley sheet, Utah, may also be used. On this consult Davis, King, and Collie, p. 12, and Gilbert's *Lake Bonneville.* The map in the pocket of the last shows these plains more broadly. Lake Bonneville is described in Sec. 154, p. 160, and Sec. 156.

River plains.—If sufficient attention has not been given to delta plains, under Rivers, the subject may be resumed here with any available maps. Marysville, Cal., is named by Davis, King, and Collie, p. 11.

159–160. **Prairie plains and the Great Plains.**—Any available maps may be used. They are in great number wherever the surveys have been carried on, and should be chosen with reference to the home State or locality. Thus in Illinois the La Salle sheet, of which a part is shown in Fig. 11, gives an interesting combination of the river plain and of the prairie plain, which, as the text explains, is of more complex origin. The *Physical Geography of the Texas Region* should be studied for the plains of that State. (Hill, folio iii, Topographic Atlas of the United States.)

Chapter VIII, Mountains and Plateaus

REFERENCES

Various text-books of geology and physical geography.

Earth Sculpture. J. Geikie.

Mechanics of Appalachian Structure. B. Willis. *Thirteenth Annual Report, United States Geological Survey.* Gives account of folds produced by laboratory experiments.

The Northern Appalachians. Willis. In *Physiography of United States.* American Book Co.

The Southern Appalachians. Hayes. *Physiography of United States.*

The Scenery of Switzerland. Lubbock. Macmillan.

The Scenery of England. Lord Avebury (Lubbock).

Scenery of Scotland. A. Geikie. Third edition.

Mountains of the Great Basin, or "block" type, due to faulting. Consult paper by I. C. Russell, *A Geological Reconnaissance in Southern Oregon, Fourth Annual Report, United States Geological Survey,* pp. 435–464.

Colorado Plateaus. Powell's *Exploration of the Colorado River,* and Dutton's *Tertiary History of the Grand Canyon District.* The last is accompanied by an atlas and forms *Monograph II, United States Geological Survey.* Other reports of western geological surveys. These are too numerous for mention in detail, but should be sought in libraries as teachers have opportunity. Such are reports of the *Fortieth Parallel Survey,* the *Wheeler Survey,* Dutton's *High Plateaus of Utah,* and Powell's *Uinta Mountains.*

Works of travel should be consulted for mountain scenery and mountain life. Supplementary reading in such volumes will naturally follow the references which deal with the origin of mountain forms. *Appalachian Ridges, Ozark Ridges, Ozark Plateau, Hogbacks, Topographic Atlas, United States Physiographic Types.* Gannett. Folio ii.

SUPPLEMENTARY EXPLANATION

Plateau, a French word meaning something flat, was first used in geography for a table-land or upland plain,

but is now applied also to broad uplands on which there are mountains.

LABORATORY EXERCISES

163–164. **Profile and structure of the Rocky Mountains in Colorado.**—Have profiles constructed across the region shown in Fig. 123. Use a base line to represent the sea-level, and take the following altitudes for data:

Altitude of Great Plains east of the range, 5,000–6,000 feet.

Altitude of the inter-mountain valleys, South Park, etc., about 8,000 feet.

Altitude of highest summits, about 14,000 feet.

Construct profiles along the parallels of Denver, Colorado Springs, and that of San Luis Park and San Juan Mountains. A complete geological section is not here meant, but the profile of the surface. The upturning of the strata at the base of the ridges should be further studied in the Topographic Atlas of the United States, *Physiographic Types,* Gannett, folio ii, *Hogbacks.*

165. **The Colorado plateaus.**—Dutton's *Tertiary History of the Grand Canyon District* and Powell's *Exploration of the Colorado River* may be used for any amount of supplementary study that time allows. More specifically, use group of sheets as follows: St. Thomas, Mount Trumbull, Kaibab, Echo Cliffs, Camp Mojave, Diamond Creek, Chino and San Francisco Mountain sheets, all of Arizona. These should be mounted together and the surface studied and described in the note-books in detail. Observe particularly altitudes, slopes of surface, escarpments and their character, and dissection of canyons.

166. **Great Basin topography.**—Fig. 129. Use for fuller study and explanation of Great Basin structure the Oregon paper by Russell, given in the list of references

for this chapter. Also Gilbert's *Bonneville,* p. 6, and Gilbert, *Wheeler Survey,* iii, 21–42, or any one of the above three references that is available. Text-books of geology should be consulted if the *fault* is not clearly understood. See also Davis, *Elementary Physical Geography,* 178–181. Further hints also in *Geography in Horace Mann Schools; Dodge and Kirchwey,* March, 1902, 93–94. Study such sheets as Tooele Valley, Utah, and Disaster and Granite Range, Nevada. Bring out in the study the linear character of the ranges, the waste plains and lake bottom deposits of the valleys, and the unsymmetrical slopes of some of the ridges. The last feature appears in Disaster sheet, as in Pine Forest Mountains and north and south of Thacher Pass. Make profile along the parallel of 41° 45′.

167. **The physiography of California.**—Points to be studied: the Sierra Nevada, the Great Valley, the Coast Range, and the abrupt descent down the west slopes of the last to the sea, without the intervention of a coastal plain. Fig. 129 will serve as the basis for drawing a rather general cross profile, including the ranges and valleys of the Great Basin as well as the great features of California above named. In this connection consult Topographic Atlas of the United States, *Physiographic Types* (folio ii, Gannett), *Alluvial Cones.* This sketch gives the explanation of much of the floor of the central valley. Note that in profile, as in photograph of the model (Fig. 129), the Sierras have a bold eastern front and a more gentle slope on the west.

169. **Study of the Mount Marcy sheet, Adirondack Mountains, New York.**—Detailed description of entire area as to (*a*) relief, and (*b*) drainage. Study the trend of the ridges, their height, and the altitude of the main valley floors. Make cross profile through Mount Marcy and Upper Ausable Lake, horizontal and vertical scale the

same. Analyze the drainage, in connection with a map of the State, assigning each part to its proper drainage system. With tracing-paper reproduce the drainage lines on a separate sheet, and note the prevailing trends. Compare other summits with Mount Marcy, and estimate the average altitude of the whole area.

170. **Appalachian folds.**—Folds may be reviewed in text-books of geology if their nature has not been sufficiently brought out in the class exercises on the text. For the resulting topography have copies of the Harrisburg sheet, Pennsylvania, sufficient for the class or the laboratory division. Here we have a section of the Appalachian Valley east and west of Harrisburg, Blue (Kittatinny farther east) Mountain, and other ridges to the northward. Study the trellising of the drainage, and make list of the streams, as transverse or longitudinal. Make a profile crossing the ridges at right angles. Also construct a profile of the water gap cut by the Susquehanna through Blue or Second Mountain. The following sheets should be mounted in a group and used for extending the study over a wider area: Sunbury, Shamokin, Catawissa, Millersburg, Lykens, Pine Grove, Harrisburg, Hummelstown, and Lebanon, all in Pennsylvania.

173. **Alleghany plateau.**—(*a*) Use the Catskill and Kaaterskill sheets, New York. The two take in the Hudson River and its lowland, the Catskill escarpment, and part of the Catskill plateau. Have the sheets studied in some detail, but with special reference to the plateau and its eastern front. Consider the Kaaterskill and Plaaterkill cloves, and the headwaters of Schoharie Creek. Note Plateau Mountain as a remnant of the upland. Compare the contoured map with the representation by shading, in Fig. 9. Use contoured map to construct the east and west profile.

(*b*) Use the Chattanooga and McMinnville sheets,

Tennessee. Note the main escarpment of the Cumberland plateau running from the upper right-hand corner of Chattanooga sheet, southwestward. Its altitude and the breaks due to erosion are points to be observed; also Lookout Mountain as a spur of the main mass to the westward. It would be well to have the Ringgold sheet to show extension of Lookout Mountain southward. Study the plateau surface and note the arrangement of drainage. Sequatchie Valley is a longitudinal valley opened on a low anticlinal fold. Beyond it the plateau is resumed. Consult Hayes, *Physiography of the Southern Appalachians,* in *Physiography of the United States,* American Book Co. Compare the sheet with Fig. 133. The figure shows more of Lookout Mountain, but takes in less territory to the north. It will be found of interest to state that Mr. Howell, the maker of the model shown in Fig. 133, has constructed for the War Department a large model of this region, which exhibits also all the military movements which took place here during the civil war. The McMinnville sheet represents a typical area of the plateau and should be briefly described, noting especially its uniformity of general surface, and its characteristic arrangement of drainage.

(*c*) Use a group of sheets showing the much dissected part of the plateau in West Virginia. The sheets are Charleston, Kanawha Falls, Nicholas, Oceana, Raleigh, and Hinton. Duplicates of one of these sheets will suffice for individual use in the exercise, but the group should be mounted and used to show in part the extent of such surface. Small areas of the drainage may be drawn with tracing paper. The trunk valleys should be studied with secondary, tertiary, or more minutely divided members of the drainage system.

170, 173. Make a northwest by southeast profile across the Appalachian Valley, the Cumberland plateau, and the

old mountains on the southeast. Choose a line near the Little Tennessee or French Broad River. Use for this the shaded map in Hayes's *Southern Appalachians,* pp. 306, 307. Supply altitudes from text of Hayes's paper, or from topographic sheets, or other available sources.

174. **Study of the Matterhorn,** with any materials accessible to the student. Its general form, its angles of slope, the hanging glaciers on its lower slopes, and its surroundings—peaks and glaciers—are points of inquiry. Use notes of travelers, guide-books, accounts of ascents and photographic or other views. Make it the center for outlining the main features of Swiss mountain ranges.

Chapter IX, Volcanoes

References

Any text-books of Geology and Physical Geography.

Volcanoes. Judd. *International Scientific Series.* Appleton.

Volcanoes of North America. I. C. Russell.

Vesuvius. John Phillips. Often to be obtained of dealers in second-hand books.

Vesuvius, Etna, and Other Volcanoes. Lyell's *Principles of Geology.* Eleventh edition. Appleton.

Characteristics of Volcanoes. Dana. Dodd, Mead & Co. Deals largely with Hawaiian volcanoes.

Hawaiian Volcanoes. C. E. Dutton in *Fourth Annual Report United States Geological Survey.*

Mount Shasta. Diller in *National Geographic Monographs, Physiography of the United States.* American Book Co.

A Young Volcanic Mountain. (Mount Shasta.) Topographic Atlas of the United States. Folio i. Gannett.

Crater Lake. Diller, *National Geographic Magazine,* viii, 33, or *Journal School Geography,* i, 266, 1897.

A Crater. (Crater Lake.) *Topographic Atlas of the United States.* Folio ii. Gannett. (Maps, views, and description.)

Lava Sheets and Mountains of the Connecticut Valley. The following are somewhat technical but will repay careful study, especially by New England teachers:

The Triassic Formation in Connecticut. W. M. Davis. *Eighteenth Annual Report United States Geological Survey,* part ii.

Geology of Old Hampshire County, Massachusetts. B. K. Emerson. Monograph XXIX, *United States Geological Survey,* pp. 351–501.

Volcanic Peaks, Plateaus, and Necks. Topographic Atlas United States Physiographic Types. Folio ii. Gannett.

Martinique number of the *National Geographic Magazine,* July, 1902.

SUPPLEMENTARY EXPLANATION

The word *volcano* is from the Latin. In Roman mythology volcanoes are workshops of Vulcan (*Vulcanus*), the god of fire and blacksmith god.

LABORATORY EXERCISES

185. **Mount Shasta.**—Use Fig. 144. See references above, especially Diller's *Mount Shasta* and Gannett's *A Young Volcanic Mountain.* Desirable to have several copies of Mount Shasta sheet for detailed study of all features. Make profile with same horizontal and vertical scale, and compare with profile in Fig. 144. Have description of glaciers written from the map before the student reads the descriptions in the text to which reference is made. Compare profile with Vesuvius or any other cone available in pictures or models. Study the gorges on the slopes of Shasta. Bring out the distribution of surface streams as controlled by the glaciers, none flowing west or southwest. Note also the subterranean drainage between the foot of the glaciers and the head of the surface streams.

187. **Library study of the eruptions of 1902 in the West Indian islands.**—Following the eruption of Mount Pelée and other disturbances, numerous accounts are found in all news journals and most weekly and monthly periodicals. Files for the summer of 1902 will yield abundant material for reports and essays by the student.

189. **Lava sheets.**—The Mount Tom-Holyoke range in Massachusetts and the Palisades ridge of the lower Hudson River may be studied. The sheets needed are the Belchertown, Northampton, and Springfield, Massachusetts, the Tarrytown and the New York and vicinity. (The latter is a special map, four times the regular size, 20 cents.) Let the general topography be described, with special attention to the form and trend of the ridges. Profiles should be constructed to emphasize the unsymmetrical character of the lava ridges, contrasting the dip slope on the east of Mount Tom with the retreating escarpment formed by its western edge. Similarly for the Palisades we have the dip slope on the west and the escarpment forming the Palisades bluffs. The teacher will understand by study of Davis and Emerson (references) the meaning of the New England peneplain, and thus be able to aid the student in following the story of the origin of the ridges by denudation, and to explain how the Connecticut has been able to cut through the range near Northampton.

190. **Crater Lake.**—Materials needed are Figs. 152, 153 of the text, and several copies of the Crater Lake special sheet, Oregon. Consult *A Crater* in *Topographic Atlas, United States Physiographic Types,* Gannett, folio ii. Two photographic views are also reproduced which may be studied in connection with the bird's-eye views of the text-book. See also Diller's papers noted in the list of references on volcanoes. Have the student describe in

detail the topography and make profile of the remnant of the mountain and the basin, including a dotted profile of Mount Mazama.

CHAPTERS X AND XI, THE ATMOSPHERE

REFERENCES

Elementary Meteorology. W. M. Davis. Ginn & Co. Best book for general consultation. Answers all questions likely to arise in the study of the text.

Practical Exercises in Elementary Meteorology. Robert DeCourcy Ward. Ginn & Co. Indispensable. Best guide to the teacher in laboratory instruction. Non-instrumental and instrumental work, map exercises, weather forecasting. Suggestions to teachers, outline of equipment, etc.

Elementary Meteorology. Waldo. American Book Co.

Popular Treatise on the Winds. William Ferrel. Useful to the teacher, too difficult for elementary students.

About the Weather. Harrington. Appleton.

Meteorology. Thomas Russell. Macmillan. Contains full accounts of floods in United States and their prediction.

American Weather. Greeley. Dodd, Mead & Co.

Atlas of Meteorology. Bartholomew. Lippincott. Expensive but of great value.

Illustrated Cloud Forms. Text and colored chart. United States Hydrographic Office, Washington, D. C.

Rainfall of the United States. Harrington. *United States Weather Bureau, Bulletin 6,* 1894.

Three pamphlets on observations and use of instruments, United States Weather Bureau, as follows:

Instructions for Voluntary Observers, 1899, pp. 23.

Barometers and the Measurement of Atmospheric Pressure. C. F. Marvin. Pp. 74.

Instructions for Obtaining and Tabulating Records from Recording Instruments, 1898, pp. 31.

Monthly Weather Review. Edited by Cleveland Abbe. 10 cents per copy. United States Weather Bureau.

For other bulletins and charts of United States Weather Bureau see Ward, *Practical Exercises,* etc., pp. 191, 192.

Elementary Meteorology. J. M. Jameson. *Journal School Geography,* ii, 2–9, 56–62, 96–104, 139–146.

Equipment of a Meteorological Laboratory. R. DeC. Ward. *Journal School Geography,* iii, 241–250.

Weather Map Exercises. M. S. W. Jefferson. *Journal School Geography,* v, 51–59.

Laboratory Work in Elementary Physiography. R. H. Cornish. *Journal School Geography,* i, 204–207.

Geography in the Horace Mann Schools. Dodge and Kirchwey. *Teachers' College Record,* March, 1901, 77–85.

Geographical Laboratory Work in Worcester Academy. W. H. Snyder. *Journal School Geography.* III. 368–375.

United States Coast and Geodetic Survey. Annual Report for 1880. Appendix V. Charles A. Schott. Gives a summary account of Map Projections, with a special discussion of the Polyconic.

APPARATUS

Full directions are given in Ward's *Practical Exercises in Elementary Meteorology,* Appendix B, pp. 186–188. As suggested by the same author, the following instruments will suffice for elementary observations. (*Practical Exercises,* pp. 11–26.)

Ordinary thermometer. (United States Weather Bureau pattern, $2.75.)

Wind vane. (United States Weather Bureau pattern, $10.)

Rain gage. (United States Weather Bureau standard, $5.25.)

Mercurial barometer. (United States Weather Bureau standard, $30 or $33.) New form especially for school use; L. E. Knott Apparatus Co., 14 Ashburton Place, Boston, Mass., $5.75.

Blank weather maps (maps of the United States with all regular Weather Bureau stations indicated) may be bought from the United States Weather Bureau, Washington, D. C. Form C.—Size, 23 × 16 inches; suitable for use of teacher before class; price, 75 cents per 100 or $7 per 1,000. Form E.—Size, 10 × 7 inches; suitable for use of students; price, $1.55 per 1,000. More advanced work will require maximum and minimum thermometers, wet- and dry-bulb thermometers, and anemometers. For continuous records, the thermograph and barograph must be had. But the four instruments named above will do well for such a course as is given in our text. Additional firms for the supply of such instruments are H. J. Green, 1191 Bedford Avenue, Brooklyn, N. Y., and Queen & Co., Philadelphia, Pa.

SUPPLEMENTARY EXPLANATIONS

199. **Humidity.**—The amount of aqueous vapor actually present in a body of air is called its *absolute humidity.* It is expressed either as the weight of vapor in a unit volume of air, or as the pressure or elastic force of the vapor. The *relative humidity* is the ratio of the vapor present to that necessary to saturate the air. They are so related that when one is known the other can be computed, provided the air temperature and pressure are also known. For certain purposes the absolute humidity is the important factor, but in the current work of the Weather Bureau the relative humidity only is used.

199, 200. **Measurement of humidity.**—In the daily work of the Weather Bureau the humidity of the air is measured at each station. The instrument used is a *psychrometer,* consisting of a pair of thermometers, one of which has its bulb wrapped in wet muslin. They are called the *dry-bulb* and *wet-bulb* thermometers. Evaporation from the wet muslin has a cooling effect, so that the

wet-bulb thermometer reads lower, and this cooling effect is greater when the air is dry than when it is moist. The readings of the two thermometers thus afford a measure of the relative humidity and also of the dew-point. The following table, condensed from Davis, shows (R. H.) the relative humidity, in percentages, and (D. P.) the dew point, in degrees, for each 10° of air temperature (dry-bulb thermometer reading), and each 2° of difference between the readings of dry- and wet-bulb thermometers:

Difference between Wet- and Dry-Bulb Readings (degrees).		Temperature of Air.										
		−10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
2	D. P.	−76	−18	−1	12	24	35	46	57	67	77	87	98
	R. H.	10	42	60	72	79	84	87	89	90	92	92	93
4	D. P.	....	....	−22	1	17	30	42	53	64	74	85	95
	R. H.	....	....	21	44	58	68	74	78	81	83	85	86
6	D. P.	....	....	....	−18	7	24	37	49	61	72	82	93
	R. H.	....	....	....	16	38	52	61	68	72	75	78	80
8	D. P.	....	....	....	....	−8	16	31	45	57	68	79	90
	R. H.	....	....	....	....	18	37	49	58	64	68	71	74
10	D. P.	....	....	....	....	....	4	25	40	53	65	77	87
	R. H.	....	....	....	....	....	22	37	48	55	61	65	68
12	D. P.	....	....	....	....	....	−16	17	35	49	62	74	85
	R. H.	....	....	....	....	....	8	26	39	48	54	59	62
14	D. P.	....	....	....	....	....	....	5	28	45	58	70	82
	R. H.	....	....	....	....	....	....	16	30	40	47	53	57
16	D. P.	....	....	....	....	....	....	−20	20	39	54	67	79
	R. H.	....	....	....	....	....	....	5	21	33	41	47	51
18	D. P.	....	....	....	....	....	....	....	8	33	50	63	76
	R. H.	....	....	....	....	....	....	....	13	26	35	41	47
20	D. P.	....	....	....	....	....	....	....	−13	25	45	60	73
	R. H.	....	....	....	....	....	....	....	5	19	29	36	42
22	D. P.	....	....	....	....	....	....	....	....	15	39	56	69
	R. H.	....	....	....	....	....	....	....	....	12	23	32	37
24	D. P.	....	....	....	....	....	....	....	....	0	32	51	66
	R. H.	....	....	....	....	....	....	....	....	6	18	26	33

210. **The warming of the atmosphere.**—Two other factors are concerned in the warming of different parts of the atmosphere. (1) Air warmed near the ground is ex-

panded and tends upward, so that heat is carried up by the circulation of the air. (2) In the process of evaporation heat is consumed or stored away in such form as not to be manifest in temperature, and this "latent" heat is liberated when condensation takes place. Thus part of the sun's heat applied to the ground is given to the air in the formation of clouds and rain. These factors combine with "dynamic heating" (Sec. 215) in determining the vertical distribution of temperature.

211. **Maximum and minimum thermometers.**—In the example given of hourly observations the highest temperature recorded was 34°, and the lowest 23°, but between the hours of observation the temperature may have risen or fallen beyond these limits. Special thermometers have been devised to record automatically the maximum and minimum temperature, and these are used in fully equipped observatories. They are in pairs and are placed with their tubes nearly horizontal. One tube has a constriction near the bulb, slightly obstructing the movement of the mercury. When the mercury expands it is forced up the tube in the usual way, but when it contracts the column breaks at the constriction, and the upper part remains to record the highest temperature reached since the last setting. A slight jarring unites the parted column. The other thermometer contains alcohol instead of mercury, and within the alcohol in the tube is a short pin, or slide, called the index. By inclining the tube the index is made to slide to the head of the alcohol column, and the instrument is then set. As the liquid contracts from cold the index is carried down with it, but when the liquid expands it flows past the index, and the position of the index thus shows the lowest temperature since the last setting. Usually the pair of thermometers are set once a day and are thus made to record the highest and lowest temperature in twenty-four hours.

216. **Reduction of temperatures to sea-level.**—On Pikes Peak (altitude 14,111 feet) the mean temperature is 19.4°. Colorado Springs, at its base (altitude 6,072 feet) has a mean temperature of 47.2°. The difference is chiefly due to difference in height. If isotherms were drawn of the surface temperatures of the State of Colorado they would follow around the mountain slopes so as to resemble contours of altitude. The same remark applies to all mountainous regions, and even to some lands of moderate relief. Such maps of surface temperatures are valuable, especially for showing climate, but they fail to bring out the control of temperature by the relations of land and water, and by ocean currents. For world maps it is better to make allowance for altitude and bring all temperatures to a sea-level basis.

217. **Projections.**—In the *cylindric projection* the earth is conceived to be circumscribed by a cylindric surface tangent to it at the equator. From the center of the sphere straight lines are run to points on its surface and continued to the cylinder, and details of the earth's surface are thus *projected* on the cylinder, making a map. The cylinder is then conceived to be divided along a line parallel to its length and unrolled, or developed, becoming a flat surface and still bearing the map.

The *Mercator projection* closely resembles the cylindric, but differs in the fact that its parallels are so spaced that at each point of the map the scale of distances is the same for all directions.

In a *conic projection* the earth is conceived to be circumscribed by a cone, tangent at some parallel of latitude, and the map is projected on the cone by straight lines from the center of the earth, after which the cone is divided and developed.

In the *polyconic projection* each parallel of latitude is separately projected, as though upon a cone tan-

gent to the earth in that latitude. The construction is otherwise too complicated to admit of a simple description.

Most modern maps are framed on one of these three plans, but for special purposes a number of other projections are used. It is the practise of map-makers to lay out a system of parallels and meridians with great care, and use them as a framework, to which all other parts are adjusted.

230. **Deflection of winds by rotation.**—The law under which the trade-winds and "westerlies" are turned from their northward or southward courses applies to all moving objects on the earth's surface and is quite general in its character. Rivers of the northern hemisphere press their right banks. A railway train on a straight track presses the right rail. When a cyclone is formed, or a whirlwind, the initial impulse of the air is directly toward the center, but each element is deflected to the right (in the northern hemisphere), and thus all unite in a spiral, whirling motion about the center, circling as they ascend, somewhat as the water about a whirlpool circles in descending. In the northern hemisphere the northern part of a cyclone or whirlwind swings westward and the southern part eastward, the rotation having a direction opposite to that of the hands of a watch or clock. In the southern hemisphere their rotation has the same direction as the hands of a watch.

Words.—Some new words grow into being by the gradual modification of old words. Others are coined outright to express new ideas. The method of coining words from classical materials is well illustrated by *thermometer, barometer, isotherm,* and *isobar,* which are built from four Greek words, *thermos* (warm), *barus* (heavy), *metron* (measure), and *isos* (equal).

The names of clouds are Latin. *Cumulus,* a heap,

cirrus, a curl, and *stratus*, a coverlet or layer, refer to form; *nimbus* means rain.

Centigrade is from the Latin *centum* (hundred) and *gradus* (step, degree), and refers to the division of the space between the freezing- and boiling-points of the thermometer into one hundred parts. The Fahrenheit scale is named from a German physicist, Gabriel Daniel Fahrenheit, who devised it. He invented the mercurial thermometer, about 1714.

LABORATORY EXERCISES

Observations of the weather.—(203, 207, 211, 216, 218–220.) Systematic observation of the weather should be begun early in the course instead of being delayed until the chapter on the atmosphere is reached. To arouse interest in those weather elements which directly affect the senses it is necessary only to draw attention to them, and a course of observation will advantageously prepare the way for the explanations of the text-book.

Having selected a time for daily attention to the subject, begin by questioning the class as to the present condition of the weather, the relation of this to the condition twenty-four hours earlier, and the prevalent conditions during the twenty-four hours. Is the air hot, warm, cool, or cold? Is it warmer or cooler than yesterday? What changes have occurred since yesterday at this time? Ask similar questions as to precipitation, cloudiness, movement of clouds, strength of wind, and direction of wind.

As a second step, have each scholar make a daily record of the weather. Select certain definite elements, have columns arranged for them, so that the same features may be followed from day to day, and have a column for general notes.

The use of instruments follows, the order of impor-

tance being: the thermometer, the rain gage, the wind-vane, the barometer. On an open prairie there is little need of a wind-vane; in a city, where the need is greatest, either a vane or a high flag is usually visible from some convenient point.

Some account of modes of observation is given below, under the appropriate section headings, but the teacher should avail himself of the fuller instructions contained in Ward's *Practical Exercises in Elementary Meteorology.*

Near the end of the work on the atmosphere, visit, if practicable, one of the stations of the Weather Bureau.

199–200. **Dew.**—On a cool day evaporate much water in a warm room and observe the dew or frost gathering on the window-panes. The warm air becomes nearly saturated, so that saturation is completed by a little cooling against the window. On a warm, moist day fill a pitcher or tumbler with ice-water, and observe the dew forming on the outside. Set a cup of hot water and a glass of ice-water on a table and cover them with a bell glass (or box); after a time observe the dew on the glass.

On a still, clear evening, after rain, when dew is to be expected, lay a board on a lawn; support another board above the grass at a height equal to the width of the board; and stretch a piece of cloth above the grass. In the morning observe the presence or absence of dew on the boards and cloth, and on the grass under them. Endeavor to explain the occurrences.

201. **Clouds.**—Note and name the kinds of clouds in the sky. Note what proportion of the whole sky is covered. Note the direction in which the clouds move, and whether their movement is slow or fast.

Watch individual clouds, and observe that they change shape (1) by motion of the air; (2) by growth, the enlargement of the field of condensation; (3) by dissipation. Observe cumulus clouds, growing beneath while dissi-

pating above. Observe a steam jet condensing to cloud as it cools by radiation and by mingling with air, and see the cloud waste away as further mingling enables the air to absorb all the moisture. Note the slower wasting on days when the air is humid.

203. **Observation of rain.**—Establish a rain gage and have daily measurements of rainfall. The standard gage is described by Ward (p. 15). A deep bucket with vertical sides may be used, and the depth measured by inserting a small rod at the middle and noting how much is wetted. To make a more precise measurement, pour the water into a narrower cylindric vessel, measure the depth, and divide the result by the ratio of the greater cross-section to the less.

207. **Observation of temperature.**—Have the class practise reading the thermometer. Train them to take the precautions necessary for precision; to avoid warming the bulb with the hand; to have the line of sight normal to the scale, so that the top of the mercury will not be projected too high nor too low; to interpolate, by eye estimate, between the markings of the scale. Install a thermometer on the north side of the building, where it can be read through the window, and protect it against the direct rays of the sun (Ward, p. 13). Use this for regular observations of outdoor temperature.

Test the freezing points of thermometers by putting them in a mixture of water and crushed ice. Take the temperature of boiling water also, if the scale reads high enough, but remember that if the tube is too short the heat will cause the mercury to burst it. Observe the temperature in different parts of the room—near the window, floor, ceiling. Explain the observed differences.

To convert centigrade degrees to Fahrenheit degrees multiply by 1.8 and add 32; or (to use an arithmetic short-cut) double, subtract a tenth, and add 32. To convert

Fahrenheit degrees to centigrade, subtract 32 and divide by 1.8. Give the class exercises in these conversions.

211. **Graphic records.**—The diagram used in this section to show the march of temperature is an example of an important class and represents a general method of graphic expression. Horizontal distances (abscissas) here stand for time, and vertical distances (ordinates) for temperature; but abscissas and ordinates may represent any other variable quantities. Drill the class in making and reading such diagrams, and vary the subject enough to illustrate the wide field of the method. For example, find how many there are in the class of each age—12, 13, 14, etc. — and have the result expressed in a diagram. Again, let abscissas stand for parts of a year, as in Fig. 168, and ordinates for the time of sunrise as shown by an almanac; the result is a curve showing the time of sunrise through the year. On the same sheet plat the curve of the time of sunset; then shade the spaces outside the two lines, and the width of the unshaded space represents the length of the day as it changes through the year. Have

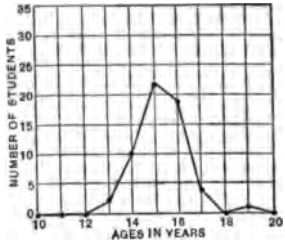


FIG. 10.—Graphic representation of the ages of members of a class.

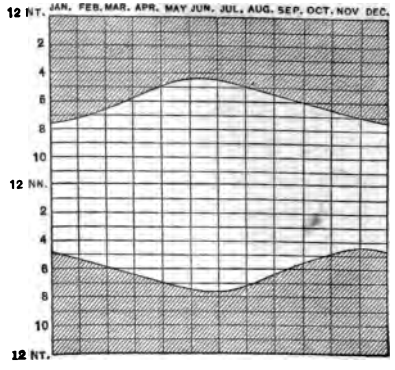


FIG. 11.—Graphic representation of the amount of day (unshaded) and night (shaded) in all parts of the year; computed for the latitude of New York.

some of the diagram sheets ruled so coarsely that interpolation will be necessary in platting the points.

Plat into curves all the weather elements observed by the class which admit of quantitative expression.

216. **Isotherms.**—The study of the July and January isotherms may advantageously be carried much farther than it is in the text-book, especially if the students are led to discover the various features for themselves. The positions of the regions of greatest cold and greatest heat, the bending of isotherms along coasts, and the crowding of heat contours when winter is on the land hemisphere, are among the features which illustrate the greater range of land temperatures as compared to oceanic.

Obtain a supply of blank weather maps (Form E) from the United States Weather Bureau so that each student can have the use of several. They will be needed for various exercises to be mentioned later. Obtain also, by application to the Chief of the Weather Bureau (or from Ward, p. 47) full reports of the temperatures and other weather data recorded at the regular stations of the Bureau, on several consecutive days. The data for a single day are given on pp. 72–76. Have the temperatures for one day platted on the maps, the numbers expressing the temperatures being written in small figures close to the several places. The next step is to draw among these numbers the isotherm for a particular temperature, say 30°. It will pass through stations marked 30°, and pass among the other stations in such way that all marked less than 30° will be on one side of it and all marked more than 30° will be on the other side. It will be a curved line, and in passing between two stations will divide the space in the ratio of the differences of temperatures. Thus, in going between the numbers 29 and 33, it will pass three times as far from the 33 as from the 29. Afterward draw the lines for 40°, 50°, etc., and 20°, 10°, 0°, –10°,

etc. These processes are elaborately explained by Ward (p. 51).

With the aid of the isotherms the distribution of temperature should now be described in words. Point out the warmest regions, the coolest regions, the regions of most rapid change. Then draw the isotherms for the following day, and by comparing the two, observe the changes which have occurred.

It will help to bring out the contrasts in temperature if the regions colder than some selected temperature, say 30°, are distinguished by a shade, and if the regions warmer than some other temperature, say 60°, are given a different shade. But such shades should not be used if isobars are to be afterward drawn over the isotherms.

Data for Weather Map of the United States, for 8 A. M. (Eastern Time), March 1, 1902

Place.	Pressure in inches.	Temperature.	Wind.		Precipitation in previous twenty-four hours (inches).
			Miles per hour.	Direction.	
Atlantic Coast States and St. Lawrence Valley					
Sydney, C. B. I.	30.20	32	8	S.	Trace
Father Point, Quebec	29.50	36	16	S. E.	.10
Quebec, Quebec	29.36	40	24	N. E.	.56
Eastport, Me	29.66	44	34	S.	.52
Northfield, Vt	29.48	44	12	N.	.64
Portland, Me	29.52	42	20	S.	2.12
Boston, Mass	29.62	48	16	S. W.	1.72
Nantucket, Mass	29.74	46	20	S.	.60
Block Island, R. I	29.70	44	22	S. W.	1.34
Binghamton, N. Y.	29.52	44	Lt.	S.	.96
Albany, N. Y.	29.58	46	8	S.	1.36
New York, N. Y.	29.64	48	10	S. W.	.44
Scranton, Pa.	29.58	44	Lt.	N. E.	1.60
Philadelphia, Pa.	29.64	52	8	S.	1.58
Atlantic City, N. J.	29.72	42	14	S. W.	.58
Baltimore, Md.	29.62	50	Lt.	S.	.82
Washington, D. C.	29.60	50	6	S.	1.08
Lynchburg, Va.	29.62	50	Lt.	S. W.	.04

Data for Weather Map of the United States (Continued)

Place.	Pressure in inches.	Temperature.	Wind.		Precipitation in previous twenty-four hours (inches).
			Miles per hour.	Direction.	
Norfolk, Va.	29.72	54	12	S.	.62
Charlotte, N. C.	29.68	46	8	S.	.04
Raleigh, N. C.	29.72	54	10	S W	.32
Hatteras, N. C.	29.80	52	20	S. W.	.38
Wilmington, N C.	29.78	58	12	S	.90
Charleston, S C.	29.76	56	8	S.	.01
Augusta, Ga.	29.68	58	Lt.	S.	.0
Savannah, Ga.	29.72	60	8	S W.	02
Jacksonville, Fla.	29.74	60	12	S.	.0
Jupiter, Fla.	29.72	68	Lt.	N.	.14
Key West, Fla.	29.80	74	Lt.	S.	.14
Gulf States					
Atlanta, Ga.	29.62	48	14	S.	.04
Macon, Ga.	29.60	58	8	S.	0
Tampa, Fla.	29.76	60	8	E.	.08
Mobile, Ala.	29.60	60	Lt.	S. E.	0
Montgomery, Ala.	29.60	56	18	S. W.	.04
Meridian, Miss.	29.52	58	16	S. W.	Trace
Vicksburg, Miss.	29.50	56	6	S. W.	0
New Orleans, La.	29.56	62	8	S.	0
Shreveport, La.	29.52	52	6	W.	0
Fort Smith, Ark.	29.50	38	8	S. W.	.01
Little Rock, Ark.	29.48	38	10	S. W.	Trace
Palestine, Texas.	29.58	54	6	N.	0
Galveston, Texas.	29.52	62	14	S. W.	0
Taylor, Texas.	29.58	48	8	W.	0
San Antonio, Texas.	29.64	56	6	S. W.	0
Corpus Christi, Texas.	29.64	58	8	N. W.	0
Ohio Valley and Tennessee					
Memphis, Tenn.	29.48	44	14	S.	.02
Nashville, Tenn.	29.50	44	10	S. W.	.06
Chattanooga, Tenn.	29.56	46	6	S.	.01
Knoxville, Tenn.	29.54	46	10	S. W.	Trace
Louisville, Ky.	29.40	42	14	S.	.14
Evansville, Ind.	29.34	40	14	S.	Trace
Indianapolis, Ind.	29.28	36	22	S. W.	.14
Cincinnati, Ohio.	29.38	44	12	S. W.	.14
Columbus, Ohio.	29.36	42	12	S. W.	.10
Parkersburg, W. Va.	29.44	50	10	W.	.02
Pittsburg, Pa.	29.40	48	10	S.	.18

Data for Weather Map of the United States (Continued)

Place.	Pressure in inches.	Temperature.	Wind.		Precipitation in previous twenty-four hours (inches).
			Miles per hour.	Direction.	
Lake Region					
Bissett, Ontario	29.32	34	0	.....	.10
Port Arthur, Ontario	29.04	10	22	W.	.28
Parry Sound, Ontario	29.18	40	12	S. E.	.18
Saugeen, Ontario	29.20	38	16	S.	.06
Oswego, N. Y.	29.44	46	14	S.	.70
Rochester, N. Y.	29.42	44	8	S.	.22
Buffalo, N Y	29.34	46	28	S.	.16
Erie, Pa	29.30	48	20	S. W.	.10
Cleveland, Ohio	29.30	44	24	S.	.02
Toledo, Ohio	29.24	40	18	S.	.04
Detroit, Mich	29.22	38	20	S. W.	.06
Alpena, Mich	29.08	36	14	S. E.	.14
Sault Ste. Marie, Mich	29.00	38	10	S. E.	.30
Houghton, Mich	28.88	26	Lt.	E.	.62
Marquette, Mich	28.88	32	6	S. W.	.48
Escanaba, Mich	28.92	32	12	S.	1.12
Green Bay, Wis	28.96	32	12	S. W.	.82
Grand Haven, Mich	29.04	34	26	S.	.44
Milwaukee, Wis	29.02	34	10	S. W.	.12
Chicago, Ill	29.10	34	24	S. W.	.08
Duluth, Minn	29.06	16	24	N. W.	.14
Upper Mississippi Valley					
St. Paul, Minn	29.06	18	12	N.	.26
La Crosse, Wis	29.02	24	10	W.	.12
Dubuque, Iowa	29.10	30	8	W.	.46
Davenport, Iowa	29.08	30	16	W.	.18
Des Moines, Iowa	29.22	24	18	W.	.10
Keokuk, Iowa	29.22	28	18	S. W.	.16
Springfield, Ill	29.24	32	20	W.	.08
St. Louis, Mo	29.30	36	24	S. W.	Trace
Cairo, Ill	29.40	40	12	S. W.	.01
Missouri Valley					
Springfield, Mo	29.38	32	16	N. W.	.04
Kansas City, Mo	29.42	26	12	N. W.	.08
Wichita, Kan	29.54	34	14	N. W.	0
Concordia, Kan	29.50	32	24	N. W.	0
Omaha, Neb.	29.34	22	20	N. W.	.08
Valentine, Neb	29.58	20	24	N. W.	Trace
Sioux City, Iowa	29.30	20	30	N. W.	.08
Huron, S Dak	29.46	14	36	N. W.	.12
Pierre, S. Dak	29.64	22	30	N.	.20

Data for Weather Map of the United States (Continued)

Place.	Pressure in inches.	Temperature.	Wind.		Precipitation in previous twenty-four hours (inches).
			Miles per hour.	Direction.	
Moorhead, Minn.	29.42	8	28	N. W.	.16
Bismarck, N. Dak.	29.76	10	34	N. W.	0
Williston, N. Dak.	29.98	10	12	N.	.30
Rocky Mountain Slope					
Battleford, Sask.	30.02	4	Lt.	S. E.	0
Havre, Mont.	29.96	22	Lt.	S. W.	Trace
Helena, Mont.	29.92	32	Lt.	S. W.	0
Miles City, Mont.	29.92	24	6	N. W.	0
Kalispell, Mont.	29.90	30	Lt.	W.	.02
Lewiston, Idaho.	30.00	36	Lt.	.....	Trace
Pocatello, Idaho.	30.04	28	6	S.	.84
Boise, Idaho	30.08	32	Lt.	S. E.	.02
Rapid City, S. Dak.	29.80	24	22	N. E.	.02
Lander, Wyo.	29.98	12	Lt.	S.	.06
Salt Lake City, Utah.	30.06	30	Lt.	E.	.22
Modena, Utah.	30.00	22	Lt.	N. W.	Trace
Grand Junction, Col.	29.98	24	Lt.	E.	.10
Cheyenne, Wyo.	29.78	22	26	N. W.	Trace
North Platte, Neb.	29.50	28	28	N. W.	0
Denver, Col.	29.74	26	Lt.	N.	0
Amarillo, Texas.	29.70	30	12	N. W.	0
Pueblo, Col.	29.70	28	8	W.	0
Dodge, Kan.	29.60	32	14	N. W.	0
Oklahoma, Oklahoma.	29.56	36	8	N. W.	0
Fort Worth, Texas	29.64	42	8	N. W.	0
Abilene, Texas.	29.68	44	12	N. W.	0
El Paso, Texas.	29.80	38	8	W.	Trace
Santa Fé, N. Mex.	29.78	24	8	N.	.01
Flagstaff, Ariz.	29.94	32	Lt.	N.	0
Yuma, Ariz.	29.94	42	Lt.	E.	0
Phœnix, Ariz.	29.94	40	0	.....	0
Pacific Coast					
Barkerville, B. Columbia.	29.74	20	0	.....	0
Victoria, Brit. Columbia.	29.92	40	0	.....	.08
Kamloops, Brit. Columbia	29.76	36	0	.....	0
Spokane, Wash.	30.00	34	8	S.	.16
Tacoma, Wash.	29.98	42	6	S. W.	.20
Portland, Ore.	30.00	42	8	S.	.42
Roseburg, Ore.	30.02	34	Lt.	E.	.12
Baker City, Ore.	30.04	24	Lt.	S. E.	.04
Carson City, Nev.	30.00	22	Lt.	N.	0
Winnemucca, Nev.	30.04	22	Lt.	N. E.	0

Data for Weather Map of the United States (Concluded)

Place.	Pressure in inches.	Temperature.	Wind.		Precipitation in previous twenty-four hours (inches).
			Miles per hour.	Direction.	
Eureka, Cal.	29.96	42	Lt.	S. W.	.32
Red Bluff, Cal.	29.96	42	Lt.	N.	0
San Francisco, Cal.	29.94	48	8	S. E.	0
Fresno, Cal.	29.98	58	Lt.	N. E.	0
Los Angeles, Cal.	30.02	48	8	N. E.	0
San Diego, Cal.	29.98	46	Lt.	N. E.	0

218. **Pressure of the atmosphere.**—Illustrate the principle of the barometer by filling and inverting a tumbler or test-tube in a basin of water and lifting it, bottom upward, to a position like that of the barometer tube in Fig. 173. Also partly fill, and invert as before.

Reading the barometer.—The barometer should be hung with the tube vertical. In place of the basin shown in Fig. 173, it has a smaller cup, called a *cistern*. The cistern has a buckskin bottom, and by means of a screw pressing against the buckskin the capacity of the cistern can be changed. When a change of air pressure causes the column in the tube to grow longer or shorter, the surface of the mercury in the cistern is lowered or raised. The first procedure in making an observation with the barometer is to raise or lower the mercury in the cistern by turning the screw until its surface is just at the zero of the scale. The height of the top of the column is then read by means of the scale at its side, in inches, tenths, and hundredths.

As the height of the mercury column also changes with temperature an allowance is made for the difference between the temperature of the instrument and 32°, which has been adopted as the standard temperature for pressure observations. A thermometer is usually mounted close to

the barometer, and its reading gives the temperature of the barometer. The amount of the "correction" is taken from a table (see Ward, pp. 166–167). If the table is not at hand the correction may be computed with sufficient approximation by the formula:

$$\text{The correction (in inches)} = -\frac{h\,(t-32)}{10{,}000},$$

in which h is the barometric pressure in inches and t the temperature of the barometer in degrees.

Special instructions for the unpacking and installation of barometers are given by their makers.

219. **Isobars.**—The process of drawing isobars is similar to that of drawing isotherms and need not be described in detail. The students should actually draw them, beginning with tabulated pressures. (The pressures are given for one day on p. 72; for five days, by Ward, p. 47.) It is well to make the first pressure map separate from the corresponding temperature map and accent it by shading; and afterward combine them without shading. Then the winds may be platted on the same sheet, as in Fig. 174, etc. Lines of study are suggested by the text. The most important are the relation of winds to barometric gradients and to centers of low pressure, the relation of temperatures to centers of low and high pressure, and the relation of temperatures to winds.

Construct the weather map for the following day or days and study the changes, especially the eastward drift of the great features.

220. **Observation of the wind** should include two parts, the direction and the strength. For direction discriminate the four cardinal points and the four intermediate points, northwest, southwest, etc. For strength use the following scale:

0. *Calm.*

1. *Light*: just moving the leaves of trees.

2. *Moderate*; moving branches.

3. *Brisk*; swaying branches; blowing up dust.

4. *High*; blowing up twigs from the ground; swaying whole trees.

5. *Gale*; breaking small branches; loosening bricks in chimneys.

6. *Hurricane* or *tornado*; destroying everything in its path.

Note currents high in the air by observing the motion of clouds. Often the lower and upper clouds move in different directions. The best observations of direction are on clouds near the zenith.

222. **Daily weather maps.**—Obtain from the Weather Bureau in Washington, or from the nearest prediction station, the daily weather map as it is issued. Study the charted weather day by day, compare each map with the preceding to note the movements of cyclones, rain tracts, cold waves, etc., and discuss the local weather in relation to the broader features of the weather of the country.

225. **Shore and gorge breezes.**—If the school is close to the ocean or to a large lake, observe the "land and sea" breezes. This will be possible only in warm, clear weather and when the general condition of the air is quiet. Watch for a reversal of the wind in the forenoon and again a little before or after sunset.

If the school is near a steep mountain front, or in a mountain gorge, a similar daily reversal of the wind can be observed. In sunshine the air against the slopes, expanded by warming, tends upward and produces a gentle current up the slopes. At night, the cool, heavy air against the ground flows down the slopes, and accumulates in the gorges, through which it often pours with much force.

227. **When a thunder-storm approaches,** assign to individuals or committees the observation and record of dif-

ferent features: clouds, their form, color, motion; rainbow; wind, its direction and strength; rain, its quantity, size of drops; hail; pressure and pressure changes; temperatures, by sensation and by thermometer; lightning and thunder, comparative strength, time between flash and associated peal; and have the time of each observation carefully noted. Afterward have the various records combined in relation to time, and a history of the storm written.

Chapter XII, The Earth's Magnetism

REFERENCES

The Earth, a Great Magnet. J. A. Fleming. *Terrestrial Magnetism,* vol. ii, No. 2, 1897. A popular discussion, partly historical.

Magnetic Declination Tables and Isogonic Charts for 1902, and Principal Facts relating to the Earth's Magnetism. L. A. Bauer. United States Coast Survey, 1902. A comprehensive treatise.

SUPPLEMENTARY EXPLANATION

Declination, in the technical sense given it on p. 275, sounds strangely because of the familiar meaning, *a refusal to accept.* It is interesting to note that the original significance of the Latin word *declinatio* is a *turning aside,* so that the students of terrestrial magnetism have merely revived an old meaning.

LABORATORY EXERCISES

237. **The declination of the needle.**—If a theodolite or transit is available, make an observation on Polaris to determine the declination of the needle. Adjust the instrument and set it up in a convenient place before dark. Take special care in leveling it. A faint light held near

the object glass of the telescope will illuminate the cross wires after dark.

The star Polaris is not at the north pole of the sky but a little to one side of it in the direction opposite to that of the star Alioth. In the constellation popularly known as the Dipper the star of the handle which is nearest the bowl of the dipper is Alioth. Point the telescope at Polaris when Alioth is either directly below it or else has the same height at right or left. Then read the direction indicated by the compass needle attached to the instrument. If Alioth is below Polaris, this direction is the declination of the needle. If Alioth is at the right, the direction is too far to the west; if at the left, too far to the east. The correction to be applied varies in amount with the latitude of the place, being $1\frac{1}{2}°$ in latitude 37° and $1\frac{3}{4}°$ in latitude 47°. From July to September the observation can be most conveniently made with Alioth at the left; from October to December with Alioth below; and from January to March, with Alioth at the right.

238. **Magnet and compass.**—To perform the experiment mentioned in the text it is best to use a straight magnet instead of one with the ordinary horseshoe form. Such magnets are made of tempered steel. A bar of soft iron, if placed parallel to the earth's axis, derives magnetism from the earth and, if large enough, will control a compass needle in similar way.

239. **Compass of iron ore.**—Bring a pocket compass near to different parts of a block of magnetic iron ore, and find its poles. Its north pole, or poles, will be found to attract the south end of the compass needle, and *vice versa*. Place the block in a pan and float it on water. It will come to rest in a particular position controlled by the earth's magnetism.

Chapter XIII, The Ocean

REFERENCES

Sea and Land. N. S. Shaler. Scribner.

The Depths of the Sea. W. Thomson. Macmillan.

The Atlantic. W. Thomson. Popular account of the Challenger Expedition. Macmillan.

Deep-Sea Sounding and Dredging. C. D. Sigsbee. United States Coast Survey.

The Fauna of the Deep Sea. Hickson in Modern Science Series. Appleton.

The Gulf Stream. Pillsbury. United States Coast Survey.

Ocean Currents. James Page. *National Geographic Magazine,* xiii, May, 1902, pp. 135–142. Excellent statement concerning surface currents.

Deep Sea Explorations. Tanner. United States Fish Commission.

Three Cruises of the Blake. A. Agassiz. Houghton, Mifflin & Co.

Pilot Charts North Atlantic and *Pacific Oceans.* Monthly. United States Hydrographic Office.

References on Tides—The Tides. G. H. Darwin. Houghton, Mifflin & Co. *Atlantic Estuarine Tides,* Jefferson. *National Geographic Magazine,* ix, 400, 497. *Waves and Tides.* Davis. *Journal School Geography,* ii, 98, 122. *Tide Tables.* United States Coast Survey.

Corals and Coral Islands. J. D. Dana. Dodd, Mead & Co.

Structure and Distribution of Coral Reefs. Charles Darwin.

Farthest North. Nansen. This and other works of polar exploration afford vivid descriptions of arctic sea ice.

SUPPLEMENTARY EXPLANATIONS

"Good round ball" (p. 279) is quoted from Horace Bushnell; essay on *The Sea,* in *Moral Uses of Dark Things.*

250. **Centrifugal force.**—The explanation here given of the tides is adapted from G. H. Darwin, who develops

the subject very clearly and fully. To understand the reasoning of the second paragraph it is important to think of the earth as *not* turning on its axis as it revolves about the point A. With rotation and revolution combined it is not true that "the centrifugal force is the same for all parts of the earth." The effect of rotation is introduced in the next paragraph.

Spring tides.—If the school is near the sea, it is well to introduce the subject of spring and neap tides. The sun produces a tide similar to the lunar but smaller. At new moon and at full moon the sun and moon act in the same direction, and the solar tide is added to the lunar, producing a maximum effect, called spring tide. At the first quarter and third quarters of the moon the directions of sun and moon differ by 90°, lunar high tide is combined with solar low tide, and *vice versa*; and there is a minimum rise and fall called neap tide.

Words.—Atlas, in Greek mythology one of the Titans, stood at the western extremity of the earth and held up the sky. His name was afterward given to a mountain supposed to stand in northwestern Africa; and the ocean beyond was called *Atlantic* (the root form of *Atlas* being *Atlant*). Magellan, after struggling with storms in passing around Cape Horn, was delighted to find fair weather beyond, and named the new-found ocean *Pacific* (peaceful).

LABORATORY EXERCISES

The nature of the subject renders it difficult to name a series of exercises strictly suited to the laboratory. As will be seen below, library work is substituted in a number of instances. The arranging of this work must depend upon the diligence of the teacher and the books available. As duplicate volumes and maps may not be at hand students may be assigned to individual exercises and exchange their materials as needed. If, however, as in 257

or others, several maps can be had, class exercises can be arranged. Very interesting class or laboratory reading and discussions are possible for some of the themes in this chapter. Such are *The History of Exploration* (253), *Navigation* (256), *Submarine Cables* (257), and *Fishing* (258). On several of these themes magazine literature is abundant. A search of a file of any of the better known periodicals will afford such articles.

240. **Study of ocean basins.**—This will be a practicable laboratory exercise when models, with rational profiles, are available. For the present, descriptions in books must be the chief reliance. See such accounts in texts of Tarr, Davis, and Dryer, and in text-books of geology. Consult also encyclopedias, as *Atlantic, Pacific,* etc., in *Encyclopædia Britannica.* In the article *Atlantic* are several profiles. From these the student may be taught to construct others, using scales to give but 5:1, 10:1, or even less exaggeration of the vertical. A still more instructive exercise may be based on the map of the Atlantic in vol. ii of Thomson's *Atlantic* (opposite title-page). This map shows in color the reliefs of the Atlantic basin, and the student should write a careful description in his notes. See also *Comparative Study of Atlantic and Pacific Oceans,* Semple, *Journal School Geography,* iii, 121–129, 172–180.

243. **Islands in the ocean.**—Have the student construct profiles from Figs. 195, 196. Soundings are not given, hence the relative depths must be treated in a general way. In 195 we shall have elevated land in the main island, shallow water in the lagoon on either hand, low land in the barrier reefs, and water on both sides descending to great depths; 196 gives a similar profile, without high land, and with one central, shallow lagoon. More definite results with Ebon Atoll, *Mid-Pacific Chart,* United States Hydrographic Office. In Dana's *Corals*

and Coral Islands, plate xi, p. 204, will enable the student to compare the soundings over the Bahama reefs, etc., with the deeper adjacent waters. Written description.

244. **Properties of sea water.**—Dissolve salt in water until the water is saturated. The resulting brine corresponds approximately to that of Great Salt Lake. Mix one pint of this brine with six pints of fresh water. The mixture corresponds in saltness to sea water. Select some object (a block of heavy wood, for example), which will barely float in fresh water. Remove it successively to the sea-water mixture and the strong brine and observe how much higher it floats on the heavier liquids. Repeat the experiment with a block of ice, representing an iceberg. On a very cold night expose equal amounts of the three liquids in vessels of the same size; in the morning observe the differences in the formation of ice.

246. **Light and color.**—Short library study. Search any works of ocean travel for good descriptive passages.

249–250. **Tidal observations.**—If the sea or a tidal estuary is near, establish a tide-gauge and make regular observations. Choose a spot not reached by large waves and, having graduated a board in feet and inches, and numbered the foot-marks, fasten it vertically on a wharf or pile with the zero below lowest water. Observe the height of the water hourly, or as often as convenient, for several days, and plat the height as a curve. Then observe the times of high water and low water daily and compare them with the time of the rising of the moon, either observing the moon-rise or taking it from an almanac. Having learned how much, on the average, the tides follow or precede the rising of the moon, predict the times of high and low tide for future days and then compare observation with prediction. Do the same for spring and neap tides, comparing them with full and new moons.

250. **To illustrate centrifugal force** attach a small weight to a string a few inches long, whirl it by the string in a horizontal circle, and feel the pull of the string. Replace part of the string near the hand by a rubber band and observe the stretching of the band when the weight is whirled.

251. **Ocean currents.**—It would be useful for the student to make a careful pencil copy of the map of the Atlantic currents, Fig. 201. For library work see Thomson, *Depths of the Sea,* chapter viii, p. 356. Also, *Three Cruises of the Blake,* vol. i, chapter xi, p. 241, with map (Fig. 174). Compare Franklin's idea of the Gulf Stream (Fig. 173). For a criticism which goes somewhat to the other extreme, see *The Gulf Stream Myth, Scribner's Magazine,* 1902. Use also Pillsbury's *Gulf Stream.*

252, 253. **Sea ice and general exploration.**—Library exercise. Here use Polar Explorations, such as Nansen's *Farthest North* or Greely's *Three Years of Arctic Service.* Our Fig. 202 is from the latter. Consult *Three Cruises of the Blake.* Chapter i gives an account of equipment; chapter ii gives a historical sketch of deep-sea work. *The Atlantic* and *The Depths of the Sea,* by Thomson, give abundant materials, as also Sigsbee's *Deep-Sea Sounding and Dredging.* It will interest students to be told that the author is Captain Sigsbee, of the old battleship Maine. Deposits in the ocean (255) are also amply treated in these volumes.

256. **Navigation.**—Study of ocean steamship routes. United States Pilot Charts, Hydrographic Office.

257. **Submarine cables.**—Study and description of the cable map of the world, published (25 cents) by the National Geographic Society, Washington, D. C.

Chapter XIV, The Meeting of the Land and Sea

REFERENCES

Sea and Land. N. S. Shaler. Scribner.

Topographic Features of Lake Shores. G. K. Gilbert. In *Fifth Annual Report, United States Geological Survey.* Also in *Lake Bonneville, Monograph I, United States Geological Survey.*

Seacoast Swamps of the Eastern United States. N. S. Shaler. *Sixth Annual Report, United States Geological Survey.*

Beaches and Tidal Marshes of the Atlantic Coast. National Geographic Monograph V, published as part of *Physiography of United States.* American Book Co.

The Geological History of Harbors. N. S. Shaler. *Thirteenth Annual Report, United States Geological Survey.*

Earth Sculpture. J. Geikie. Putnam. Chapter xv.

Scenery of England. Lord Avebury. Chapter iv.

Scenery of Scotland. A. Geikie. Chapters on the Scottish Coast-line.

Shore-line Topography. F. P. Gulliver. *Proceedings of American Academy of Arts and Sciences,* 34, 351.

A Model of Seashore Characteristics. G. C. Curtis. *Journal School Geography,* vol. ii, 1898, pp. 215–227.

The Atlantic Coast and its Lighthouses. R. E. Dodge. *Journal School Geography,* vol. ii, 1898, pp. 62–66.

Organization and Methods of the United States Life-saving Service. By Sumner F. Kimball, Superintendent of the Service. Pamphlet, 33 pp. Government Printing Office.

LABORATORY EXERCISES

259. **Shore-line of Maine.**—For this study consult in a preliminary way any good atlas map of the entire State. For special study use the Boothbay and Bath sheets. Fig. 206 is taken from the former. Note the details lost by reduction, such as small islands, minor indentations of the shore-line, and the contours. Note the trend of the

bays, islands, and mainland ridges, and consider the location of Bath and Brunswick. Have the area described in the notes with as much detail as is permissible. The origin of the forms may be discussed, as in many other cases, both in class and laboratory. On the Coast Survey map of this region study the soundings. (For the coast survey charts needed in this and subsequent exercises the teacher is referred to Davis, King, and Collie's *Governmental Maps in Schools*, pp. 46–49, where the most important charts are briefly described, the numbers given, and directions for purchase.) The Casco Bay, Small Point, and Monhegan sheets will afford further study along the adjacent shore-lines.

260. **Shore-line of Massachusetts.**—A variety of useful exercises are possible here, with a supply of maps. The Geological Survey sheets of the entire shore-line of the State, with those adjoining on the west and north, may be profitably mounted in two or three groups. The writer has a northern group as follows: Newburyport, Haverhill, Gloucester, Salem, Lawrence, Boston Bay, Boston, Duxbury, Abingdon, Dedham. If the class or division is small, such a grouped map may be used for successive study by several students, the rest meantime being occupied with other exercises. Or, duplicates may be secured of some of the more important sheets, as Boston Bay and Boston. The rough shore-line of Cape Ann, compared with the long and smooth Plum Island and Salisbury Beach and the tidal marshes, are points for study. The point to which rivers are tidal may be roughly told by following them up to where the first contour line crosses them. The tide limit would be somewhat below this point. On the Boston and Boston Bay sheets, take account of much "made" land about Boston, and study the beaches, as Nahant (see also Fig. 207), Revere, Winthrop, Nantasket, etc. Note that some headlands are rocky, as Nahant

and Marblehead Neck, while others, as Point Allerton, are of glacial accumulation, like the drumlin islands of the harbor (Sec. 260). Other details of study will suggest themselves to the teacher.

To the south, the following constitute a good group: Provincetown, Wellfleet, Chatham, Yarmouth, Barnstable, Nantucket, Muskeget. Duplicates should be had of the first two for special study of the forms of the cape. Teachers desiring to give intensive study to Cape Cod should read *Geology of Cape Cod,* N. S. Shaler, *Eighteenth Annual Report, United States Geological Survey,* part ii, and *The Outline of Cape Cod,* W. M. Davis, *Proceedings American Academy Arts and Sciences,* vol. xxxi, 1896, 303–332.

A southern group includes the following: Plymouth, Middleboro, Taunton, Providence, Falmouth, New Bedford, Fall River, Narragansett Bay, Martha's Vineyard, Gay Head. This group gives the rough shore of Buzzards Bay, the smooth lines of Martha's Vineyard, and the fiorded shores of Narragansett. All of these groups are of course illustrative of many features of the lands as well. The Coast Survey charts should not be overlooked. Duplicates are advised for Martha's Vineyard and Gay Head. See Davis, King, and Collie for Coast Survey charts. No. 6 is a general chart for New England, with more detailed maps for special parts of the shore.

261. **New York and New Jersey.**—Secure the special map, New York and Vicinity, United States Geological Survey, 25 cents. From this map a model was made, of which Fig. 208 is a photographic reproduction. Coast Survey chart No. 8 gives Long Island and New Jersey with New York Harbor. Accompanying Volume IV, *Final Report Geological Survey, New Jersey,* on the *Physical Geography of the State* is a relief map, valuable for shore-line as well as inland features. Previous exercises

will have suggested to the teacher suitable points for the student's inquiry.

262. **South Atlantic and Gulf coasts.**—Materials, grouped sheets of the Chesapeake (p. 50), Coast Survey charts (Davis, King, and Collie, p. 48), and for the Gulf Coast, Mobile Bay (Coast Survey No. 188) and R. T. Hill's *Physical Geography of the Texas Region* already named. If the delta of the Mississippi has not been studied previously it may come in here. (*Mississippi River Commission Map, and Coast Survey, No. 194.*)

263. **For the Pacific shore-line** the main reliance must at present be the Coast Survey charts—viz., San Francisco and Monterey Bays (No. 675), and fiords and islands of Southern Alaska (No. 8100).

271–272. **Coast-lines of rising and sinking lands.**—The principle involved will have been noticed in previous exercises, but may well be gathered up and emphasized by a special study of the Harvard geographical models if they are a part of the equipment. A descriptive pamphlet (Boston Society of Natural History, 25 cents) will fully suggest an outline of study. No. 1 should be studied first and then compared with 2 and 3, noting in detail the changes due to upward and downward movements.

275. **Harbors and cities.**—The report on harbors, by Shaler (see references) will suggest good exercises, being fully illustrated with maps, many of them reproduced from the Coast Survey, with soundings.

Chapters XV and XVI, The Earth and Organisms

The geographer does not study living forms to learn the details of their structure or to perfect himself in their classification, but rather to know them in a large way as related to the earth. The subject is not therefore favorable for distinctive laboratory exercises with the material

likely to be available for elementary work. But much may be made of supplementary reading, and with this in view the references that follow are, so far as possible, correlated with the sections of Chapters XV and XVI. Short essays and abstracts should be prepared and the laboratory periods devoted largely to reading, writing, and discussions. The subjects are among the most important and interesting in the entire course and should in no case be slighted.

GENERAL REFERENCES ON ORGANISMS

Stanford's *Compendium of Geography and Travel.* Many passages in all the volumes, as Gannett's on the United States, Dawson's on Canada, and the volumes relating to other continents.

Nature and Man in America. N. S. Shaler.

Story of Our Continent. N. S. Shaler. Ginn.

Man and his Work. A. J. Herbertson. Black.

The Origin of Species. Darwin.

Darwinism. A. R. Wallace.

Distribution of Animals. Heilprin. Appleton.

Island Life. A. R. Wallace. Macmillan.

Travels in the Malay Archipelago. A. R. Wallace. Macmillan.

Zoögeography. Beddard. University Press, Cambridge.

International Geography. Mill. Appleton.

Plant Relations. Coulter. Appleton.

Animal Life. Jordan and Kellogg. Appleton.

Chapters or sections on the distribution of animals and plants in text-books of zoology and botany.

Many reports of the United States Department of Agriculture. Details can not be given here, but teachers are advised to request of the department that the Monthly List of Publications be sent to them. It will be forwarded regularly to all interested persons who thus apply for it, and without charge. The production of various crops, the importations of new grains and fruits, forestry, road-making, and irrigation are among the subjects frequently treated in these publications.

Races of Man. Peschel. Appleton.

Applied Geography. J. S. Keltie. George Philip & Son, London.

The Earth as Modified by Human Action. G. P. Marsh. Scribner.

Some Geographic Causes determining the Location of Cities. E. C. Semple. *Journal School Geography,* i, 225–231.

The *Journal of School Geography* and other available geographical periodicals will furnish many valuable articles in this field.

SPECIAL REFERENCES AND EXERCISES ON ORGANISMS

278. **Forests of North America.**—Many publications of the Bureau of Forestry, United States Department of Agriculture. Gannett's *United States,* in Stanford's *Compendium,* pp. 102–105, with forest map of United States. Dawson's *Canada* in same series, several passages, see index. *Mountains of California* and *Our National Parks,* both by John Muir and published by Houghton, Mifflin & Co. *Forest Preserves,* large volume, with case of maps, *Twenty-first Annual Report United States Geological Survey,* part v, abounds in information as to Western forest lands.

279. **Forestry.**—The latest and best summary is *Practical Forestry,* by John Gifford, Appleton. Principles of forestry well treated, and includes chapter on Federal and State reservations. Schools of forestry are maintained at Cornell, Yale, and on the Biltmore estate of North Carolina. See on schools, *Bulletin American Geographical Society,* vol. xxxiii, December, 1901, pp. 450–452. *Aspects of the Earth* (Shaler) has a chapter on the forests of North America.

283. Such simple studies of grouping as are suggested by Fig. 222 may be made in field trips near the school. Seek for a similar belting of vegetation on the borders of lake or stream. Lily pads, cattail flags, willows, and

upland trees will not be an infrequent combination. Let the students record fully what they see of plant distribution in the home neighborhood.

Have them study also the influence of the home environment on the activities, industries, and routes of man. Why is a town or city located at this place? Is there water-power to invite manufacture? Is there a port or a navigable river for commerce by water? Is there a joining of easy routes for travel and land commerce? Is there a crossing of railways in a rich agricultural district? What considerations have determined the location of roads and railways? What are the leading industries, and why? What commodities are produced and consumed at home; what are imported; what are exported; and what are the reasons?

285–287. **Distribution of animals, especially in North America.**—It will be found a useful exercise if the student be asked to make a written description of the distribution of certain forms as shown in the maps (Figs. 226 and 231). Consult all available references. A few of the more accessible are here named: *Stanford's Compendium of Geography,* United States, Gannett, pp. 110–117. This passage contains a good account of the buffalo. For Canada, see *Stanford's Compendium,* Canada, Dawson, pp. 54–67, where the quadrupeds, birds, and fishes are separately treated.

288–295. **Conditions of life.**—For plants read Coulter's *Plant Relations,* especially chaps. xi to xv.

296. **Tendency to spread.**—Written descriptions of the progress of the English sparrow in the United States, as shown in the map (Fig. 236). In New England, and particularly in Massachusetts, studies of the gipsy-moth will be profitable in this connection.

297. **Struggle for existence.**—Read and discuss Darwin's chapter on this subject, *Origin of Species,* chap. iii.

298–299. **Migration and barriers.**—Consult any works on distribution. Good short discussions in Redway's *New Basis of Geography,* chap. iv. See also Darwin, *Origin of Species,* chap. xii.

302–318 (chap. xvi). Good general references here are, Adams's *Commercial Geography* (Appleton), and *Man and his Work,* by Herbertson. For the various foods, particularly grains and fruits, consult *Journal School Geography* and other periodicals; also the year-books of the Department of Agriculture and Keltie's *Applied Geography,* chap. v, "Some Common Commodities." The last contains a somewhat full account of wheat. The history of various grains and fruits may be studied in Willis's *Practical Flora* (American Book Co.).

In connection with the topics, clothing, tools, shelter, and travel, works on primitive man should be consulted. Such are E. B. Tylor's *Primitive Culture* and *Early History of Mankind;* Lubbock's *Prehistoric Times;* Lyell's *Antiquity of Man*; Tylor's *Anthropology* (more brief and popular than his *Primitive Culture*); and *Some First Steps in Human Progress,* Starr (Flood and Vincent). On clothing see also Keltie's *Applied Geography,* chapter on Common Commodities, pp. 148–156, giving an account of cotton and wool.

For sections 308 and 309, travel, communication, etc., see as follows: *Teaching of Geography,* Geikie, parts of chap. x, history of roads and postal communications; *Great Canals of the World, Journal Geography,* February, 1902, p. 122; *Submarine and Land Telegraphs of the World, Journal Geography,* September, 1902, p. 317. The good roads movement and the progress of rural free delivery are set forth in recent publications of the Department of Agriculture (see year-books and monthly list of publications).

The teacher can now find considerable material dealing

with geography in its relations to American history. Note the following:

Histories of Parkman and John Fiske. Both authors are keenly appreciative of the dependence of man's life upon the physical characters of the land which he was finding and subduing.

Winning of the West. Theodore Roosevelt.

Nature and Man in North America. Shaler.

Story of Our Continent. Shaler.

Southern Appalachians, by Hayes, and *Southern New England,* by Davis, *National Geographic Monographs,* deal mainly with land forms, but close with good accounts of human relations.

Eastern Gateway of the United States. A. P. Brigham, in *Journal School Geography,* vol. iv, p. 127, and *Geographical Journal,* May, 1899 (*Physiography and History of Mohawk Valley*).

The Shenandoah Valley and the Civil War. F. V. Emerson. *Journal School Geography,* vol. v, 1901, p. 208.

Influence of the Appalachian Barrier upon Colonial History. E. C. Semple. *Journal School Geography,* vol. i, p. 33.

Some Geographic Causes determining the Location of Cities. Semple. *Journal School Geography,* vol. i, p. 225.

MISCELLANEOUS EXERCISES

It may be again suggested that few teachers will find time or materials for all the practical exercises and supplementary readings suggested for the several chapters. On the other hand, valuable exercises, not in the list, will be devised, and some may profitably embrace features treated in several parts of the text. A few such are suggested below:

Map of school or other grounds, using compass for direction and pacing for distances.

Written descriptions of local geography.

Contoured maps made from models.

Models in sand, clay, plaster, or cardboard, made from contoured maps.

Hachured maps drawn from contoured maps.

Description of country from selected sheets of United States Topographic Atlas. Many of these have been named for special exercises. All these and any others can be used for the more general study and written descriptions here intended.

Descriptions of features shown by Harvard geographical models, or other models which may be available.

PRONUNCIATIONS

KEY.—āle, senāte, ȧm, ärm, ȧsk, finạl, ạll; ēve, ēvent, ĕnd, fern, recẹnt; īce, ĭll; ōld, ŏbey, ôrb, ŏdd; ūse, ūnīte, ŭp; fo͝od, fo͝ot; out, oil; *ch*air; *g*o; *y*es.

Agassiz (ăg'a-sē).
agave (ȧ-gā'vē).
agua (ä'wä).
anemometer (ăn'ē-mŏm'ē-tĕr).
Arapahoe (ạ-răp'a-hō).
arroyo (ȧr-roi'ō).
Artois (ȧr'twä').
Ausable (ô-sȧ'bl).
bayou (bī'o͞o).
Bedouin (bĕd'o͞o-ĭn).
Bonneville (bŏn'ĕ-vĭl).
butte (bū̇t).
Calais (Me.) (kȧl'ĭs).
Caracas (kȧ-rä'kȧs).
Chelan (chē-lȧn').
cienaga (sē'ĕn-ȧ'gȧ).
cirrus (sĭr'rŭs).
cotidal (kō̇-tīd'al).
coulée (ko͞o-lā').
crevasse (krȧ-vas').
cumulus (kū'mū̇-lŭs).
Diablo (dē-ȧb'lō).
flord (fyôrd).
Furca (fo͝or'kȧ).
Geikie (gē'kĭ).
glacier (glā'shẹr).
Gloucester (glŏs'tẹr).
gradient (grā'dĭ-ẹnt).
Guadeloupe (ga'da-lo͞op').
hachure (hȧch'ū̇r).
Hawaii (hȧ-wī'ē).
Himalaya (hĭm-ȧ'la-ya).
isobar (ī'sō̇-bȧr).
isogonic (ī'sō̇-gŏn'ĭc).
isotherm (ī'sō̇-therm).
Kilauea (kē'lou-ā'ä).
Krakatoa (krä'kä-tō'ä).
Lipari (lĭp'ạ-rē).

Llano Estacado (lyä'nō ĕs-tä-kä'dō).
loess (les).
Magellan (mạ-jĕl'ạn).
Malpais (mȧl'pīs).
Manitoba (mȧn-ĭ-tō-bä').
Mazama (mȧ-zä'mȧ).
Mercator (mer-kā'tŏr).
mesa (mā'sȧ).
moraine (mō̇-rān').
moutonnée (mo͞o-tŏn-nā').
Navajo (nä'vä-hō).
Pelée (pĕl-ā').
Piedmont (pēd'mŏnt).
placer (plȧs'er).
playa (plä'yȧ).
Pompeii (pŏm-pā'yē).
Puget (pū'jẹt).
rio (rē'ō).
Saguenay (sȧg'ẹ-nā).
Samoyed (sȧm'oi-ĕd).
San Juan (sȧn ho͞o-ȧn').
San Luis Rey (sȧn lo͞o-ēs' rā).
Santa Catalina (sȧn'tȧ kä-tä-lē'na).
Santa Maria (sȧn'tä mä-rē'ȧ).
Sawatch (sȧ-wȧch).
Soufriere (so͞o-frĭ-ār').
strata (strā'tȧ).
Stromboli (strŏm'bō̇-lē).
Tahiti (tä-hē'tē).
talus (tā'lŭs).
tepee (tē'pē).
Tibet (tĭ-bĕt').
tundra (to͞on'dra).
Uncompagre (ŭn'cŏm-pä'grē).
vlei (vlī).
Watchung (wä-chŭng').
Wasatch (wä'sȧch).

INDEX

Adirondacks, 54.
Alioth, 80.
Alleghany plateau, 55.
Animals, distribution, 92.
Appalachian Mountains, 55.
Apparatus, 3; for weather observations, 61; to illustrate gorge development, 28.
Atmosphere; suggestions on Chapters X and XI, 60.

Barometer, 61, 76.
Books, 2, 7. (See also *References.*)
Boulders, 45, 46.
Buildings, weathering of, 87.

Cables, submarine, 85.
California, mountains and valleys, 54.
Centigrade degrees, conversion of, 69.
Centrifugal force, 81, 85.
Clinometer, 28.
Clouds, 66, 68.
Coastal plain, 50.
Coasts, 86.
Colorado plateaus, 53.
Compass, magnetic, 80.
Contour maps, 21.
Crater lake, 59.
Crystalline rocks, 17.
Currents, ocean, 85.
Curvature of the earth, 13, 18.

Day and year, 22.
Declination of the needle, 79.
Degree, length of, 16.
Deltas, 31.
Density of the earth, 17.
Dew, 68.
Distribution of animals, 92.
Divides, 29.
Drainage types, 32.
Drift, 45.
Drumlins, 48.
Dunes, 40.

Earth; suggestions on Chapter I, 13.
Earth and organisms; suggestions on Chapters XV and XVI, 89.
Earth and sun; suggestions on Chapter II, 21.
Earth's magnetism, 79.
Eclipse of the moon, 18.
Ellipse, 23.
Equinoxes, 22.
Equipment of the school, 3; of the teacher, 1.
Eskers, 47.
Etymologies, 43, 52, 58, 66, 79, 82.
Excursions, 10. (See also *Laboratory exercises.*)
Explanations, by chapters: the earth, 13; the earth and sun, 32; rivers, 26; weathering and soils, 34; glaciers, 42; mountains and plateaus, 52; volcanoes, 58; atmosphere, 62; earth's magnetism, 79; ocean, 81.

Feldspar, 37.
Field work. (See *Laboratory exercises.*)

Flood-plains, 30.
Forests, 91.

Gorge, 27.
Gorge breezes, 78.
Gorner glacier, 43.
Gulf coast, 89.
Gulf Stream, 85.
Glaciers, 41.
Granite, 37.
Graphic records, 70.
Great Basin, 53.
Green, H. J., 62.
Greenland ice-sheet, 44.

Harbors, 89.
Howell, Edwin E., 4, 5.
Humidity, 62.

Ice, arctic, 85.
Islands, oceanic, 83.
Isobars, 77.
Isotherms, 71.
Instruments. (See *Apparatus.*)
Interpolation, 19, 71.

Kames, 47.

Laboratory equipment, 3.
Laboratory exercises, 10; on the earth, 18; on the earth and sun, 23; on rivers, 27; on weathering and soils, 35; on wind work, 39; on glaciers, 43; on plains, 50; on mountains and plateaus, 53; on volcanoes, 58; on the atmosphere, 67; on the earth's magnetism, 79; on the ocean, 82; on the meeting of land and sea, 86; on organisms, 91; miscellaneous, 94.
Lake filling, 31.
Lake plains, 51.
Lakes, 49.
Land and sea breezes, 78.
Lantern and views, 4.
Latitude and longitude, 14, 18, 19.
Lava sheets, 59.
Life, 89.
Limestone, 36.
Longitude, 16, 18, 19.

McAllister, T. H., 4.
Magellan's expedition, 14.
Magnet and compass, 80.
Magnetism of the earth, 79.
Maine shore-line, 86.
Man, 89.
Mapping of the weather, 62, 71, 77.
Map projections, 65.
Maps, 5, 94; how to obtain, 5; contour, 21; blank, for weather work, 62.
Marble, 36.
Massachusetts shore-line, 87.
Matterhorn, 57.
Meanders, 30.
Meeting of land and sea, 86.
Migration, 92, 93.
Minerals, 35, 37.
Mississippi River, 33.
Models, 5.
Monuments, weathering of, 37.
Mountains and plateaus, 52.

Navigation, 85.
New Jersey shore-line, 88.
New York shore-line, 88.

Observation of the weather, 67, 69, 76, 77, 78; of tides, 84.
Ocean, 81.
Orbital dates, 22.
Organisms, 89.

Pacific shore-line, 89.
Photographs, 4, 43.
Physical geography, position in school course, 11.
Pictures, 4, 7; of rocks, 34.
Plains, 41.
Plateaus, 52.
Pole-star, 22, 79.
Prairies, 51.
Pressure of the atmosphere, 76.
Projections, 65.
Pronunciations, 96.

Quartz, 35.
Queen and Co., 62.

Rau, William H., 4.
References, general, 7; on the earth, 13; on the earth and sun, 21; on rivers, 25; on weathering and soils, 34; on wind work, 39; on glaciers, 41; on plains, 49; on mountains and plateaus, 52; on volcanoes, 57; on the atmosphere, 60; on the earth's magnetism, 79; on the ocean, 81; on the meeting of land and sea, 86; on organisms, 90–94.
River plains, 51.
Rivers, 25.
Rocks, 17, 34.
Rocky Mountains, 53.
Rotation and winds, 66.

Sand, blown, 39.
Sandblast, 40.
Sandstone, 35.
School, equipment of, 3.
Sea, 81.
Seasons, 24.
Sea water, 84.
Shale, 36.
Shasta, Mount, 58.
Shore breezes, 78.
Shores, 86.
Slides, lantern, 4.
Soils, 34.
Solstices, 22.
Specimens, 7, 38.
Spring tides, 82.
Standard time, 23.
Striæ, glacial, 46.
Struggle for existence, 92.
Suggestions, by chapters, 13.
Summer schools in geography, 3.
Supplementary explanations. (See *Explanations.*)

Teacher, equipment of, 1.
Temperature of atmosphere, 63.
Temperatures, subterranean, 17.
Terrestrial magnetism, 79.
Thermometers, 61, 62, 69.
Thunderstorms, 78.
Tides, 81, 84.
Time, standard, 23.
Topics, order of, 11.

Volcanoes, 57.

Waste mantle, thickness of, 38.
Waterfalls, 30.
Weather maps, 62, 78; data for, 72.
Weather observations, 67, 69, 76, 77, 78.
Weathering and soils; suggestions on Chapter IV, 34.
West India eruptions, 59.
Wind gage, 61, 69.
Wind observations, 77.
Wind vane, 61.
Wind work, 39.
Winds, deflection by rotation, 66.
Words, origin of technical, 43, 52, 58, 66, 79, 82; pronunciations, 96.

THE END

TWENTIETH CENTURY TEXT-BOOKS.

A Text-Book of Geology.

By Professor ALBERT PERRY BRIGHAM, of Colgate University. 477 Pages. 295 Illustrations. 12mo. Cloth, $1.40.

This superb text-book is the best account for secondary schools of the earth's marvelous origin, of the processes that brought the ordered world out of chaos, and of the phenomena of geologic evolution—considered dynamically, structurally, and historically. The planet's life history is told with directness, brevity, and pedagogic fitness. The text is supplemented with 295 exquisite photographic illustrations, many taken by Professor Brigham for this work. An exceptional success in text-book writing and text-book making.

"Brigham's Geology is the cleanest cut and best pedagogical text-book for the high school that I have seen."—*C. H. Richardson, Hanover, N. H.*

"Most interesting. Decidedly the most practical book that I have seen for use in high schools."—*Miss S. A. Edwards, Philadelphia High School for Girls.*

I consider it the best written and best illustrated book I have ever seen for secondary schools."—*C. F. Warner, Mechanics Arts High School, Springfield, Mass.*

"The most attractive text-book of Geology for secondary schools that I have seen. The illustrations are a delight."—*Belle Sherman, Ithaca High School, Ithaca, N. Y.*

"It is magnificent. I consider it superior to any other book of the kind in illustrations, text, and adaptation to field work."—*Mrs. L. L. W. Wilson, Philadelphia Normal School.*

"In every way fully equal to any of the splendid series of Twentieth Century Text-Books. Many of the illustrations are new and their execution is perfect."—*R. I. Schiedt, Professor of Geology, Franklin and Marshall College, Lancaster, Pa.*

D. APPLETON AND COMPANY, NEW YORK.